Energy and Sustainability Statement

(inc. LBRuT Sustainable Construction Checklist, Decentralised Energy Network Feasibility, Passive Design Analysis & LZC Feasibility Study)

WB Sheils Ltd

Kneller Hall
Twickenham
TW2 7DU

SRE

Version	Revision	Date	Author	Reviewer	Project Manager
1	A	11/04/2022	Harrison Notter	Olivia Martinez	Harrison Notter
	B	01/092022	Yin Mui Tang	Elsa Withnell Sophie Hopwood	Bo Yang
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	D	26/09/2022	Yin Mui Tang	-	Bo Yang

The figures within this report may be based on indicative modelling and an assumed specification outlined within the relevant sections. Therefore, this modelling may not represent the as built emission or energy use of the Proposed Development and further modelling may need to be undertaken at detailed design stage to confirm precise performance figures. Please contact SRE should you have any questions, or should you wish further modelling to be undertaken post planning.

SRE Registered Office | Greenforde Farm

Stoner Hill Road | Froxfield

Petersfield | Hampshire | GU32 1DY

01730 710044

info@sre.co.uk

www.sre.co.uk

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Executive Summary

Executive Summary

This Energy and Sustainability Statement has been written to demonstrate the measures incorporated into the design of the Proposed Development at Kneller Hall, Twickenham, which will deliver lower energy and water use, lower carbon emissions and lower operational costs than a Building Regulations compliant design, in line with local policy requirements.

The energy strategy has been developed by following the GLA Energy Hierarchy of Lean, Clean, Green and Seen. The chosen energy strategy includes Lean passive and active design measures and Green LZC technologies. All new elements within the Proposed Development, including the new teaching block, sports centre, sports pavilion, and extensions to the main Kneller Hall building and school hall, will achieve a site-wide 35% improvement over Baseline CO_2 emissions on site in line with Building Regulations 2021 Part L V1 and the carbon aspirations set in the London Borough of Richmond Upon Thames Local Plan.

In advance of the submission of the full planning application, as part of the pre-application discussions an Energy Strategy Note was prepared by SRE and reviewed by the Council's independent advisors. Written feedback was received, which has been taken into consideration in the preparation of the final energy strategy.

Site-Wide	CO_2 emissions (t/yr)	Improvement over baseline (%)
Baseline	39.2	-
Lean	37.7	3.83
Clean	37.7	3.83
Green	8.8	77.56

Table 1 - Summary of the site-wide CO_2 emissions and improvement over Baseline from GLA carbon emissions reporting spreadsheet for the new developments

Site-Wide	CO_2 emissions (t/yr)	Improvement over baseline (%)
Baseline	41.0	-
Lean	38.5	6.1
Clean	38.5	6.1
Green	33.8	17.56

Table 2 - Summary of the site-wide CO_2 emissions and improvement over Baseline from GLA carbon emissions reporting spreadsheet for the existing buildings

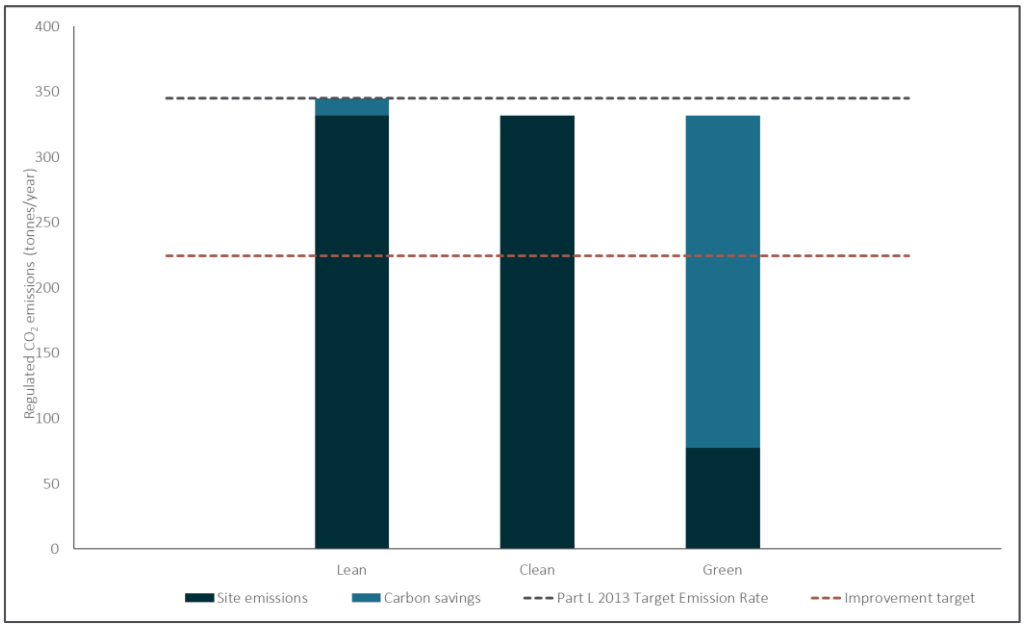


Figure 1 - Summary of regulated carbon dioxide savings for the new developments

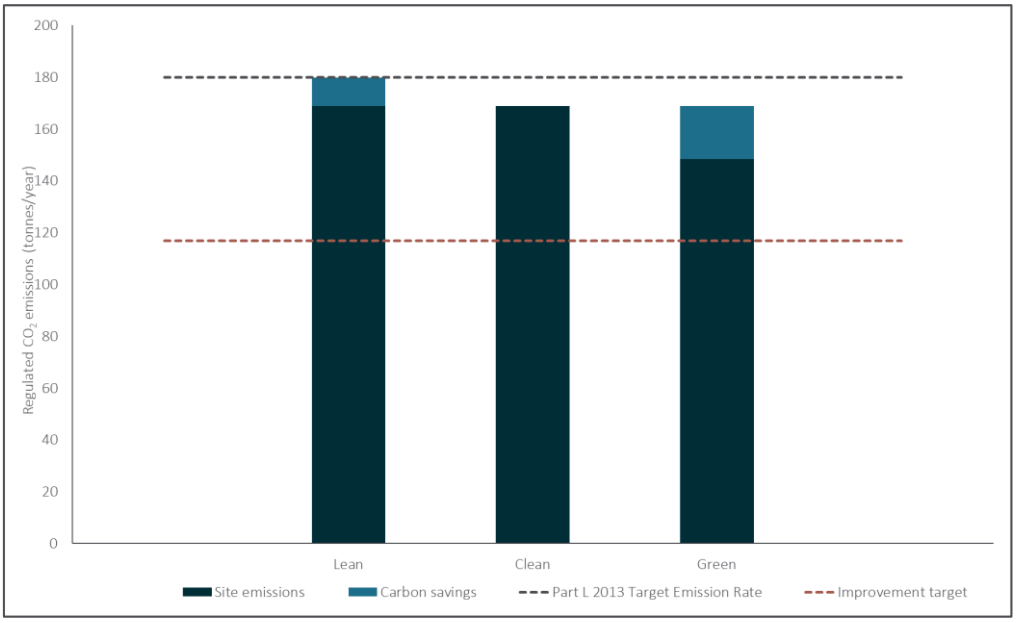


Figure 2 - Summary of regulated carbon dioxide savings for the existing buildings

Passive and active design measures will be incorporated into the design of the building, and a 246.54 kWp PV system will be installed on the roofs of the Teaching Block, Sports Centre, and Sports Pavilion, maximising the space on the main flat roof of the new buildings. The proposed energy strategy for the Proposed Development is summarised below:

Existing Buildings:

- High efficiency LED Lighting with automatic controls
- Connection to the high efficiency site wide communal heating system (heat pump) supplying heating and hot water distribution via centralised cylinders

Proposed New Developments:

- Enhanced building fabric in line with LETI guidance

- High efficiency LED Lighting with automatic controls
- MVHR ventilation (where required)
- Comfort cooling via ASHP (where required)
- Connection to the high efficiency site wide communal heating system (heat pump) supplying heating and hot water distribution via centralised cylinders
- Roof mounted PV for Teaching Block, Sports Centre, and Sports Pavilion

Further integration for the use of:

- PV battery storage

Introduction

1.0 Introduction

This Energy and Sustainability Statement has been written by SRE on behalf of WB Shiels Ltd for Dukes Education (the Client), to demonstrate the measures incorporated into the design of the refurbished and new build development at Kneller Hall, Twickenham (the Proposed Development). These will deliver lower energy and water use and associated carbon emissions that performs better than a Building Regulations Compliant design.

The statement compares the notional building with the proposed building energy requirements, taking into account energy efficiency measures and the suitability of low and zero carbon (LZC) technologies in order to address the relevant planning policy requirements.

2.0 The Site and Proposed Development

The Kneller Hall project comprises of development of 6 no. buildings consisting of the demolition of various existing buildings, construction of 3 new buildings and the refurbishment and renovation of 3 further buildings which are Grade II and the curtilage listed buildings.

The Proposed Development situated in Twickenham, Richmond Upon Thames marks the closure of the previous Kneller Hall Royal Military School nearly 170 years after its opening in 1857. The site will be converted and developed into a new educational facility through the development of new modern structures and the incorporation of the Grade II listed house and two ancillary curtilage listed buildings.

Figure 3 below illustrates the layout of the Proposed Development.

Figure 3 – Proposed site plan (ADP Architecture)

Kneller hall is found within the locality of Whitton in close proximity to Twickenham Stadium. Outside the site boundary, houses are predominantly semidetached or terraced from the inter-war period. The area is further characterised by large front gardens, now converted to off-street parking, tree lined streets and generous rear gardens.

Planning Policy	Requirement
London Borough of Richmond upon Thames – Local Plan 2020	Policy LP 20 Climate Change Adaption A. The Council will promote and encourage development to be fully resilient to the future impacts of climate change in order to minimise vulnerability of people and property. B. New development, in their layout, design, construction, materials, landscaping and operation, should minimise the effects of overheating as well as minimise energy consumption in accordance with the following cooling hierarchy: • minimise internal heat generation through energy efficient design • reduce the amount of heat entering a building in summer through shading, reducing solar reflectance, fenestration, insulation and green roofs and walls • manage the heat within the building through exposed internal thermal mass and high ceilings • passive ventilation • mechanical ventilation • active cooling systems (ensuring they are the lowest carbon options). • Opportunities to adapt existing buildings, places and spaces to the likely effects of climate change should be maximised and will be supported Policy LP 22 Sustainable Design and Construction A. Developments will be required to achieve the highest standards of sustainable design and construction to mitigate the likely effects of climate change. Applicants will be required to complete the following: • Development of 1 dwelling unit or more, or 100sqm or more of non-residential floor space (including extensions) will be required to complete the Sustainable Construction Checklist SPD. A completed Checklist has to be submitted as part of the planning application. • New non-residential buildings over 100sqm will be required to meet BREEAM 'Excellent' standard. • Proposals for change of use to residential will be required to meet BREEAM Domestic Refurbishment 'Excellent' standard (where feasible). Reducing Carbon Dioxide Emissions B. Developers are required to incorporate measures to improve energy conservation and efficiency as well as contributions to renewable and low carbon energy generation. Proposed developments are required to meet the following minimum reductions in carbon dioxide emissions: • All new major residential developments (10 units or more) should achieve zero carbon standards in line with London Plan policy. • All other new residential buildings should achieve a 35% reduction. • All non-residential buildings over 100sqm should achieve a 35% reduction. From 2019 all major non-residential buildings should achieve zero carbon standards in line with London Plan policy. Targets are expressed as a percentage improvement over the target emission rate (TER) based on Part L of the 2013 Building Regulations. C. This should be achieved by following the Energy Hierarchy:

Planning Policy	Requirement
	• Be lean: use less energy • Be clean: supply energy efficiently • Be green: use renewable energy Decentralised Energy Networks D. The Council requires developments to contribute towards the Mayor of London target of 25% of heat and power to be generated through localised decentralised energy (DE) systems by 2025. The following will be required: • All new development will be required to connect to existing DE networks where feasible. This also applies where a DE network is planned and expected to be operational within 5 years of the development being completed. • Development proposals of 50 units or more, or new non-residential development of 1000sqm or more, will need to provide an assessment of the provision of on-site decentralised energy (DE) networks and combined heat and power (CHP). Where feasible, new development of 50 units or more, or new non-residential development of 1000sqm or more, as well as schemes for the Proposal Sites identified in this Plan, will need to provide on-site DE and CHP; this is particularly necessary within the clusters identified for DE opportunities in the borough-wide Heat Mapping Study. Where on-site provision is not feasible, provision should be made for future connection to a local DE network should one become available. Applicants are required to consider the installation of low, or preferably ultra-low, NOx boilers to reduce the amount of NOx emitted in the borough. Local opportunities to contribute towards decentralised energy supply from renewable and low-carbon technologies will be encouraged where appropriate. Retrofitting E. High standards of energy and water efficiency in existing developments will be supported wherever possible through retrofitting. Householder extensions and other development proposals that do not meet the thresholds set out in this policy are encouraged to complete and submit the Sustainable Construction Checklist SPD as far as possible, and opportunities for micro-generation of renewable energy will be supported in line with other policies in this Plan.
The New London Plan (2021)	Policy SI2 Major developments should be net zero-carbon in accordance with the energy hierarchy. A minimum on-site reduction of 35% with at least 15% through energy efficiency (Lean) measures alone for non-residential development. Initially, non-residential developments may find it more challenging to achieve significant on-site carbon reductions beyond Part L 2021 to meet both the energy efficiency target and the minimum 35 per cent improvement. This is because the new Part L baseline now includes low carbon heating for non-residential developments but not for residential developments. However,

Planning Policy	Requirement
	planning applicants will still be expected to follow the energy hierarchy to maximise carbon savings before offsetting is considered[1] If zero-carbon cannot be met onsite, a shortfall should be provided either through a cash lieu contribution to the borough or off-site provided that an alternative proposal is identified, and delivery is certain.
	Policy SI 4: Managing Heat Risk Limit internal heat gain through the cooling hierarchy Policy G5: Urban Greening Major development proposals should contribute to the greening of London by including urban greening as a fundamental element of site and building design, and by incorporating measures such as high-quality landscaping (including trees), green roofs, green walls and nature-based sustainable drainage. The Mayor recommends a target score of 0.4 for developments that are predominately residential, and a target score of 0.3 for predominately commercial development (excluding B2 and B8 uses).

Table 3 - Summary of local planning policy requirements

Policy Interpretation

The Proposed Development is deemed to be a Major Development by the Local Authority due to the overall size of new construction and existing refurbishment. Therefore, in accordance with the New London Plan and local Policy requirements as required by the London Borough of Richmond Local Plan, the following standards are proposed to be met by the Development:

- Utilise the Energy Hierarchy to derive the energy strategy.
- Review and assess the development under the cooling hierarchy
- Maximise carbon savings through energy efficiency measures before the implementation of LZC technologies or consideration of offsetting (for new building elements only) (The New London Plan)
- Minimum of a 35% improvement over Building Regulations Part L standards (The New London Plan)
- Sustainable Construction Checklist (Policy LP 22)
- Any shortfall from zero-carbon standard be provided either through a cash lieu contribution to the borough (for new buildings only) (The New London Plan)

The Proposed Development will aspire to exceed the requirements as set out in the local planning documentation through the provision of sustainable, energy efficient development. The Sustainable Construction Checklist has been completed and forms an appendix to this report.

As stated in the GLA Energy Assessment Guidance Cover Note, non-residential developments may initially find it more challenging to achieve significant on-site carbon reductions beyond Part L 2021 to meet the 15% energy efficiency target. This is because the new Part L baseline now includes low carbon heating for non-residential

[1] Part L 2021 and the Energy Assessment Guidance 2022 – cover note
https://www.london.gov.uk/sites/default/files/energy_assessment_guidance_cover_note_june_2022_july_update.pdf

developments. However, the Proposed Development will implement measures in line with the energy hierarchy to maximise carbon savings before offsetting is considered.

All new elements within the Proposed Development, including the new teaching block, sports centre, sports pavilion, and extensions to the main Kneller Hall building and school hall, will achieve a site-wide 35% improvement over Baseline CO_2 emissions on site in line with Building Regulations 2021 Part L V1 and the carbon aspirations set in the London Borough of Richmond Upon Thames Local Plan.

BREEAM Assessment

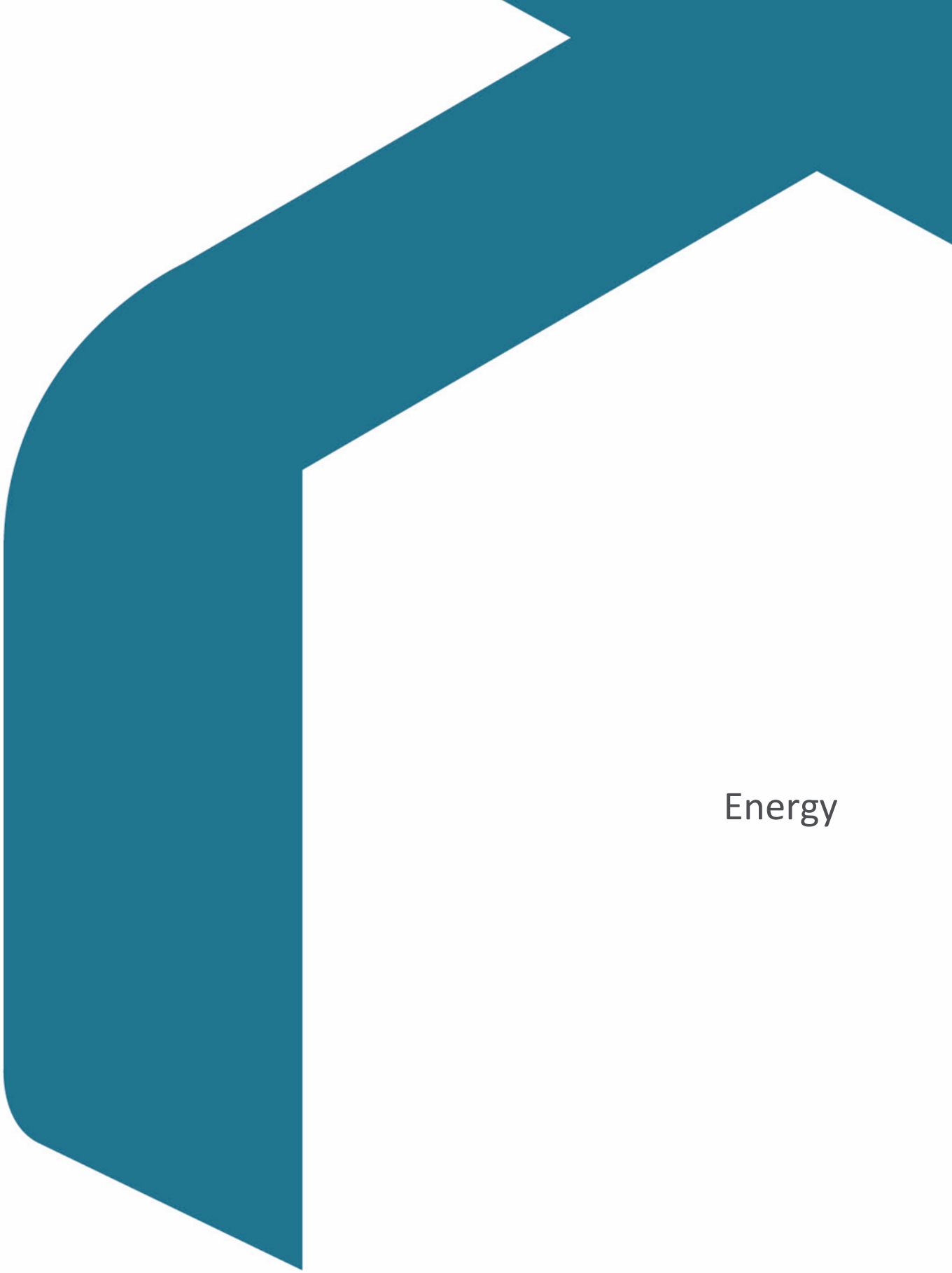
This statement is accompanied by a BREEAM pre-assessment to demonstrate the targeted measures for this development.

Although the minimum standards for an 'Excellent' rating have been met by the retained and upgraded buildings within the Proposed Development, the overall target score for the BREEAM RFO element of the project is currently 65.50%, which will deliver a robust 'Very Good' rating. The credits targeted are considered by SRE and the design team to be realistic and challenging but also deliverable on-site.

There is only one remaining 'Potential Credit' still listed within the following section. This is Hea 01 but is high risk in terms of delivering all the criteria within the credit and it is only attributable to 0.84%.

Even if this potential credit is achieved, the overall target score is still well below the threshold 70% so an Excellent rating is not possible for the retained change of use and refurbished units.

BREEAM standards can be challenging to achieve, and the pre-assessment should be carefully reviewed by the design and construction teams to ensure all targeted credits are delivered as the project is progressed. Sections 4.0 and 5.0 list the specific credits proposed as part of the BREEAM 'Very Good' rating.



Energy

3.0 Energy

3.1 Method

The energy strategy design follows guidance as outlined within the London Plan 2021, and seeks to be:

Lean

minimise the overall environmental impact and energy use through energy efficiency measures

Clean

ensure that energy systems on-site (heat & power) are efficient & produce minimal CO_2 emissions

Green

Implement suitable technologies to provide renewable and emission free energy sources

Seen

incorporate monitoring through SMART metering and accessible displays

As a new build construction, the scheme is to be assessed under Building Regulations 2021 Part L Volume 2.

The CO_2 Conversion Factors have been taken from the new Building Regulations 2021. Within the IES VE 2022 dynamic modelling, the CO_2 conversion factor for electricity varies over the course of the year due to the changing mix of inputs to the electricity grid, i.e. increased PV generation in the summer months. Whereas the carbon factors in the GLA carbon emissions reporting spreadsheet have been based on standard yearly figures taken from the Government SAP Guidance[2] and outlined below in Table 4. Therefore, there is some discrepancy between the two results.

	CO_2 Conversion Factor ($kgCO_2/kWh$)
Electricity (mains)	0.136
Electricity (offset)	-0.136
Gas (mains)	0.210

Table 4 - CO_2 conversion factors by energy source

The energy modelling for the Proposed Development has been calculated using IES VE 2022 software in accordance with Building Regulations 2021 Part L V2.

When calculating building performance, SBEM modelling will always create a Notional Building Model, which the proposed development must out-perform to meet Building Regulations Standards. The notional building provides the energy baseline and is the exact size and shape of the Proposed Development but is based on existing and/or notional U-values and heating specifications outlined in Approved Document L and the non-Domestic Building Services Compliance Guide.

For the new buildings, the Target Emission Rate (TER) from the Green scenario is taken as the energy baseline and is the exact size and shape of the Proposed Development but is based on notional U-values and heating specifications outlined in Approved Document L[3].

[2] The Government Standard Assessment Procedure for Energy Rating of Dwellings Version 10.2 (Table 12, Pg 182): https://files.bregroup.com/SAP/SAP%2010.2%20-%2017-12-2021.pdf

[3] https://www.london.gov.uk/sites/default/files/gla_energy_assessment_guidance_june_2022_0.pdf

For existing buildings the Target Emission Rate (TER) from the Green scenario is taken as the energy baseline but with notional specifications assumed, as per Appendix 3 of the GLA Energy Assessment Guidance, and which is based on Approved Documents L1 and L2.[4]

The Baseline represents the minimum compliance level in terms of Building Emissions Rate (BER) and Building Primary Energy Rate (BPER) for the Proposed Development, with all improvements measured from this level.

	CO_2 emissions (t/yr)
Baseline (New Development)	39.2
Baseline (Existing Buildings)	41.0

Table 5 - Baseline CO_2 emissions

3.2 Unregulated Energy

The unregulated energy use within a development is the energy used within the Proposed Development which has not been accounted for within Building Regulations compliance modelling. This includes auxiliary equipment such as computers, device charging, cooking etc. A summary of this energy use and related CO_2 emission is given below.

	Energy use (kWh/yr)
Unregulated energy (New Development)	230,026
Unregulated energy (Existing Buildings)	251,116

Table 6 – Unregulated energy use

[4] https://www.london.gov.uk/sites/default/files/gla_energy_assessment_guidance_june_2022_0.pdf

3.3 LEAN – Demand Reduction

The lean scenario can achieve a 3.83% reduction in CO_2 emissions using passive and active design measures. Please see Appendix C and D for the Energy-Use Intensity (EUI) and space heating demand of the Proposed Development. Although this is less than the targeted 15% reduction in CO_2 emissions for non-residential developments, this target was expected to be difficult to achieve as per the Part L 2021 and the Energy Assessment Guidance 2022 cover note. 'Lean' measures have therefore been maximised where feasible, including highly efficient building fabric with proposed U-values in line with LETI guidance, high efficiency LED lighting with average efficacies of 125 Lm/W, highly efficient MVHR systems, increased thermal mass, among the proposed 'Lean' measures. These proposed measures are further discussed in the following sections.

	CO_2 emissions (t/yr)	Improvement (%)
Baseline	39.2	
Lean	37.7	3.83

Table 7 – Lean CO_2 emissions and improvement over Baseline (New Developments)

	CO_2 emissions (t/yr)	Improvement
Baseline	41.0	
Lean	38.5	6.1

Table 8 – Lean CO_2 emissions and improvement over Baseline (Existing Buildings)

3.3.1 Passive Design Measures

Passive design measures have been enhanced where possible throughout the site to maximise building efficiency within the confines of the site constraints and budget requirements. The building has been positioned within the site to maximise the usable space, both for the internal and external spaces. The proposed new buildings are positioned with a North-South orientation to maximise solar gain where this is possible within the site boundaries.

Building	Glazing Percentage (%)
Teaching Block	36.7
Main Kneller Hall Building Extension	32.7
School Hall Extension	48.5
Sports Centre & Pool	28.2
Sports Pavilion	15.9

Table 9 - Glazing percentages for the new buildings

The design will maximise natural light and positive solar gains with glazing on the south, east and west elevations. Natural ventilation will also be provided through openable windows which will give purge ventilation to the buildings thus balancing the overheating risks. The glazing percentage for the new buildings are summarised in Table 10 below. All glazed areas of the building will have elements of shading provided by the building form or internal curtains. Solar gains will be further controlled through Low E glazing and a low glazing g-value.

Kneller Hall is Grade II listed and the Guards House and Band Practice Hall are curtilage listed. Early on in the design development, through dialogue with the project architect and heritage consultant it was confirmed that due to these buildings' historic significance and special interest, that it would not be appropriate to enhance the U-values of the buildings. The exact construction method is yet to be determined but is likely to be of timber frame construction for the sports pavilion, and steel frame construction for the other new buildings. All new building elements will be very well insulated for all external elements and have a low infiltration rate. Elements of the existing structure will be retained and left unchanged for the external building elements of the listed and curtilage listed buildings.

The proposed U-values below for the new building elements have been based on the LETI guidance. It is expected that no insulation will be added to the existing elements of the existing listed buildings, therefore the U-values remain unchanged.

Elements & U-Values	Notional Compliance	Proposed
External Walls	0.28	0.14
Ground Floor	0.22	0.10
Roof	0.18	0.10-0.12
Windows and rooflights	1.60	0.80 (g-value = 0.30)
External Doors	2.2	1.20
Air Tightness @ 50 N/m^2	15 (m^3/hr/m^2)	3 (m^3/hr/m^2)

Table 10 - Fabric energy efficiencies for new elements

Elements & U-Values	Existing unchanged
External Walls	2.4
Ground Floor	1.2
Roof	2.3
Windows and rooflights (Retained)	4.8
External Doors (Retained)	3.0

Air Tightness @ 50 N/m^2 (New)	25 (m^3/hr/m^2)

Table 11 - Fabric energy efficiencies for existing elements

The high-quality design of the Proposed Development will reduce the energy demand of the building, thus reducing the operational cost to the building occupants.

3.3.2 Active Design Measures

The Proposed Development will utilise 100% low energy/LED lighting in excess of Building Regulation requirements. External lighting, where installed, will also be energy efficient, and will be positioned to avoid excessive light pollution and be supported by PIR/daylight sensor and/or time controls to reduce operation times and subsequent energy use and emissions. Internal lighting will typically have automatic occupancy and daylight sensing control to minimise unrequired usage with local user manual override to accommodate specialist requirements. (blackout, etc.)

Centralised heat pumps are proposed as the heating and hot water strategy hence will be discussed further in the 'Be Green' section of the report under Section 3.5.

In modern air-tight buildings, careful consideration needs to be given to the specification of ventilation systems to ensure moisture is removed from the building and ensure ventilation standards are met and a healthy standard of internal air is maintained.

Mechanical Ventilation with Heat Recovery (MVHR) is provided to the new teaching block and sports centre, and some spaces in the existing school hall and guards house to provide continuous air changes with minimal heat loss. MVHR removes the warm, damp air from kitchen and bathroom spaces and passes this over a heat exchanger whereby incoming fresh air is prewarmed, before being distributed to the occupied spaces within the building. The system will also allow internal areas to be conditioned and maintain internal CO_2 levels in classrooms below the standards set out in BB101.

Openable windows will provide additional fresh air and purge ventilation to all the existing teaching spaces. Standard mechanical extract will be provided to all WC's and staff kitchen areas. A summer bypass is also to be specified whereby the heat exchanger is bypassed at times of high temperatures to provide fresh air directly to the occupied rooms. This, in conjunction with natural ventilation through window openings, will minimise the risk of overheating during times of high temperatures.

Details of the systems used in the modelling are specified in the specification sheet in Appendix B.

3.3.3 Cooling

The cooling hierarchy has been used to ensure that passive building design has been optimised to reduce the cooling load for the Proposed Development.

Active cooling is proposed for some of the teaching block dining hall, activity and fitness studio in the new sports centre, and school hall auditorium. With all of the above passive measures taken into account, cooling may not be required to the majority of spaces. However, it was still considered necessary to provide cooling due to the location and the use of some of the spaces with high anticipated internal gains. However, this has been implemented in an energy efficient way by using the low carbon air-source heat pump. This system utilises the same equipment as the anticipated space heating system serving some of the spaces.

Cooling Hierarchy	Potential Design Measures
Minimising internal heat generation through energy efficient design	All primary pipework to be insulated, therefore low system losses. High specification hot water cylinder installed with low heat loss. High efficacy low energy lighting throughout with minimal heat output.

Reducing the amount of heat entering the building in summer	Low E glass windows and internal blinds are to be provided to minimize solar gain. All new external walls are to be well insulated with a high level of air tightness to reduce heat entering the building.
Use of thermal mass and high ceilings to manage the heat within the building	Thermal mass is anticipated to be medium, internal ceilings will have exposed mass in the new teaching block.
Passive Ventilation	Openable windows will be provided to all occupied rooms.
Mechanical Ventilation	Standard extract will be proposed for all WC and bathroom facilities to comply with building regulations Part F. MVHR with summer bypass proposed to provide supply and extract ventilation to selected spaces in the new teaching block, sports centre, existing school hall, and guards house.

Table 12 - Design measures following the cooling hierarchy

An overheating risk assessment has been carried out to demonstrate compliance with CIBSE TM52. The results of the assessment are included in Section 7.0 and show that the assessed units in the new teaching block comply with the requirements set out in CIBSE TM52, BB101 and BREEAM NC 2018 Hea04. Comfortable temperatures are anticipated to be achieved under current weather conditions with minimal risk of overheating.

3.4 CLEAN – Heating Infrastructure

Early on in the design development, the feasibility of a decentralised energy network was explored, and options considered and assessed. This assessment confirmed that the Proposed Development does have sufficient heat demand to meet the requirements that would allow a communal heating system to operate to its maximum efficiency. Centralised heat pumps are proposed as the heating and hot water strategy – as heat pumps are considered a green technology, the CO_2 emissions reduction associated with the use of centralised heat pumps are included and discussed in the 'Be Green' section of the report under Section 3.5. Therefore no further improvement over the 'Clean' scenario has been recorded.

Although the Proposed Development is not located within an area with an existing or proposed district heating system, a communal wet system will allow the school to connect to a district heating scheme in the future should one become available. Therefore, the implementation of a communal system has been proposed for the site.

	CO_2 emissions (t/yr)	Improvement (%)
Baseline	39.2	
Clean	37.7	3.83

Table 13 - Clean CO_2 emissions and improvement over Lean (New Developments)

	CO_2 emissions (t/yr)	Improvement (%)
Baseline	41.0	
Clean	37.7	6.1

Table 14 - Clean CO_2 emissions and improvement over Lean (Existing Buildings)

3.4.1 District Heating

The Proposed Development is located within a Heat Network Priority Area as indicated below but is not located near to an existing district heating scheme, nor to proposed schemes or distribution routes.

The layout and configuration of the site does allow for the implementation of a district heating network because of the large scale of plant needed to serve the site.

The location of the Kneller Hall development is not currently close enough to any district heating network to allow for a feasible connection. The heating system will be designed to have centralised boiler plant, which will allow the school to connect to a district heating scheme in the future should one become available. Therefore, the connection to, or implementation of a network district heating scheme for the site has not been considered further at this stage.

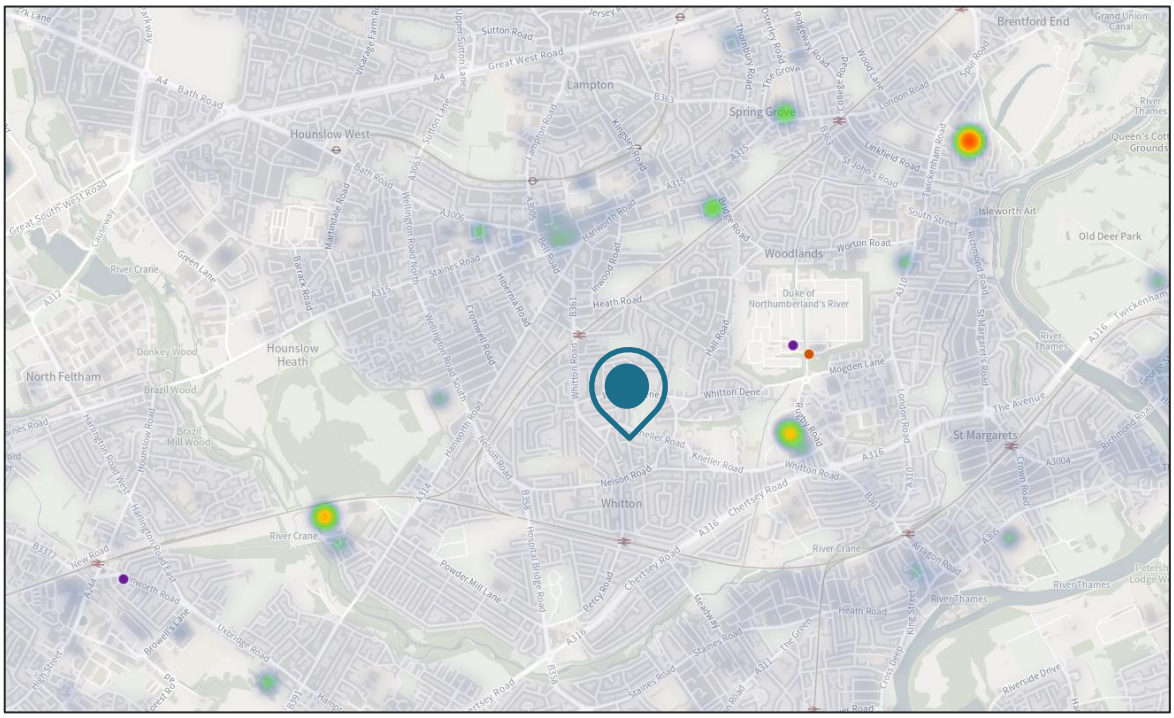


Figure 4 - London Heat Map output showing Application Site (https://maps.london.gov.uk/heatmap

3.4.2 Combined Heat and Power (CHP)

Combined Heat and Power (CHP) plant comprises an engine, usually driven by Natural Gas, coupled to an electrical generator. Electricity is generated for the use of the building and the hot engine jacket water can be utilised in heating systems, leading to very high efficiencies for the generated power. The generator electrical output is connected directly to the incoming mains supply after the meter and thereby reduces the metered electricity consumption.

The implementation of a CHP strategy should be decided according to good practice design. Key factors for efficient implementation of CHP system are:

- Development with high heating load for the majority of the year.
- CHP operation based on maximum heat load for minimum 10 hours per day.
- CHP operation at maximum capacity of 90% of its operating period.

For CHP to be viable, it has to achieve a minimum number of hours of operation each year. Controls and loads must be designed to maximise run times and to ensure that the base electrical load is always available. When the generated electricity cannot be used, the excess is automatically exported to the National Grid. Although this can be sold back to the supply authority by means of suitable export meters, it is not generally considered economically viable for small scale plants. Where heat energy cannot be used, either the plant has to be switched off or excess heat "dumped". Some dumping is allowable, whilst still maintaining the Government's assessment of a good quality scheme.

Kneller Hall is a relatively large-scale development with the multiple existing and proposed new buildings across the site and will have the base load heating demand necessary to make a CHP economical. Additionally, as a swimming pool is proposed as part of the development works, a CHP would provide a benefit for the heat generated and can be used to provide heating for the pool water temperature.

However, CHP units typically have servicing and maintenance costs similar to the costs of the energy saved by the units. With the potential intermittent use of the facilities, with the lack of a summertime load due to the school holidays, this may not be a viable option as the CHP plant will not operating to its maximum efficiency if it doesn't have the year-round heat base load. In addition, there are noise considerations on such a confined site within close proximity to other residential dwellings. If the heat cannot be used, running the plant to generate only electricity is inefficient in terms of both cost and carbon.

The use of CHP has therefore been discounted.

3.4.3 Community Heating

Community heating involves distributing space and water heating services throughout the development served from a central plant, making use of higher efficiencies available from larger systems.

As the site is considered a major development it would benefit from a site-wide communal system due to the high anticipated heat load. Therefore, it is feasible for the scheme that heating and hot water be supplied through a centralised communal system, servicing the entire site. The use of a site-wide centralised heating plant increases efficiencies and reduces fuel consumption compared to individual systems. The use of communal heat pumps has been proposed for the heating and hot water strategy. This is further discussed in the 'Green' section in Section 3.5 as it integrates the use of low carbon and renewable technologies.

The Proposed Development is of a sufficient size to allow a heat pump communal heating and hot water systems to be effective. The design and layout of the scheme is suited for the installation of a site-wide system, due to the space and high anticipated load. Therefore, the application of communal systems has been proposed for this development. The proposed energy centre for where the site-wide communal heating plant will be located is shown in Figure 5 and highlighted in yellow. The energy centre will deliver centralised heating and domestic hot water for the entire site (existing and proposed buildings) for all phases.

Additionally, the use of a small-scale communal network provides future possibilities to be interlinked to form a larger neighbourhood scale network, if a district heating main is supplied in the future.

Figure 5 - Proposed energy centre location within the site

3.5 GREEN – Low Carbon and Renewable Energy

The addition of 'Green' technologies can provide a significant reduction in CO_2 emissions and enable the new buildings of the Proposed Development to meet the threshold of 35% improvement over Baseline emissions in line with the New London Plan. A combination of ASHP and PV has been proposed to meet this requirement.

	CO_2 emissions (t/yr)	Improvement (%)
Baseline	39.2	
Green	8.8	77.56

Table 15 - Green CO_2 emissions and improvement over Clean (New Developments)

	CO_2 emissions (t/yr)	Improvement (%)
Baseline	41.0	
Green	33.8	17.56

Table 16 - Green CO_2 emissions and improvement over Clean (Existing Buildings)

	Primary Energy Rate (PER) (kWh/m^2/yr)	Improvement (%)
Baseline	392.14	
Green	76.05	80.6

Table 17 - Building Primary Energy Rate and improvement over Baseline (New Developments)

	Primary Energy Rate (PER) (kWh/m^2/yr)	Improvement (%)
Baseline	468.59	
Green	78.05	83.34

Table 18 – Building Primary Energy Rate and improvement over Baseline (Existing Buildings)

3.5.1 Heat Pumps

The use of heat pumps are often the most direct method of reducing CO_2 emissions for a Proposed Development with minimal change in aesthetics or the way in which a building is designed. Often a 'straight swap' alternative for a gas system boiler, the use of heat pumps have the potential to provide significant offset in CO_2 emissions.

All Heat Pump systems consume electricity to operate - the Coefficient of Performance (CoP) of the system is the ratio of electrical energy consumed, to heat energy emitted. Generally, a CoP of 3 or 4 can be achieved, meaning 3 or 4 units of thermal energy are produced for each unit of electricity consumed.

Heat pumps will only deliver low grade heat (up to ~50°C) efficiently, and therefore HP systems alone are generally relatively inefficient in providing hot water, as this requires additional electrical input (immersion or increased compressor use).

The use of a centralised heat pump system has been proposed as a 'Green' LZC technology to provide space heating and hot water to the new and existing buildings in the Proposed Development. This will be provided through a combination of the use of an Air Source Heat Pump (ASHP) system, Ground Source Heat Pump (GSHP) system, and local Water Source Heat Pumps (WSHPs) in individual buildings.

A centralised ASHP system, located in the energy centre, will provide a circulating ambient loop around site to serve the sports centre, school hall, and main Kneller Hall building. These buildings will have local WSHPs to take or reject heat from the loop to create each building's Low Thermal Hot Water (LTHW) or Chilled Water (CHW) system. The new teaching block, guards house, and sports pavilion, on the other hand, will be connected directly to the GSHP loop.

Through the use of heat pumps to provide space heating and hot water, there is potential to provide the following CO_2 emissions improvement for the new buildings. The specifications used in the modelling for the proposed heat pumps have been specified in the SBEM summary sheet in Appendix B.

3.5.2 Air Source Heat Pump

Air Source Heat Pumps (ASHP) have been proposed to provide space heating and hot water to the sports centre, school hall, and main Kneller Hall building, subject to the provision of underfloor heating systems (air-to-water systems) for the new sports centre, and oversized radiators for all other spaces. ASHPs efficiently extract energy from the air and transfer it into water for heating. ASHPs tend to generate some noise and therefore will be

located in an acoustic enclosure concealed on site to prevent visual impact and noise disturbances to the building's occupants and neighbours.

3.5.3 Ground Source Heat Pumps/Water Source Heat Pumps

Ground Source Heat Pump (GSHP) have been considered and proposed for the Proposed Development to provide both space heating and hot water to the new teaching block, guards house, and sports pavilion. The heat emitters are to be via oversized radiators.

Ground Source Heat Pumps (GSHPs) efficiently extract energy from the ground and transfer it into water for heating. The ground arrays for GSHPs can be either horizontal or vertical. Horizontal arrays are typically buried 1.5m to 2.0m and require significant areas of open ground; vertical arrays are set within 100m deep boreholes typically spaced 20m apart and require significantly less area of open ground.

Beyond 5 to 6m below undisturbed ground level, an average temperature of 10 degrees Celsius is maintained throughout the year[5]. Because of the ground's high thermal mass, it stores heat from the sun during the summer. GSHP can transfer this heat from the ground into a building to provide space heating. This is a similar process to an air source system transferring ambient air temperature into the heating system.

GSHP can provide a greater efficiency performance than ASHP, however it does incur higher capital cost, due to the extensive pipework needed: several 6 inch to 8 inch diameter pipes into few 100m deep boreholes. Initial discussions have taken place with a GSHP manufacturer. Further consultation with the GSHP manufacturer and an assessment of the site's ground conditions will take place to agree the detailed design before a system is installed.

As the heat pump equipment is located internally and all external pipework is buried, GSHPs have no external visual or noise issues. GSHPs are therefore considered suitable for this project.

3.5.4 Photovoltaics

Photovoltaic (PV) panels convert energy from daylight into direct (DC) electrical current. These are generally roof mounted and provide electrical generation which can either be utilised directly on-site (or nearby), stored in batteries, or exported back to the National Grid.

The installation of PV could be used to offset electrical demand within the Proposed Development. The PV array would be connected into the electrical system via an inverter or series of inverters, depending on system size and setup.

Noise will not be an issue – A PV system does not feature moving parts and is silent during operation.

An investigation into the roof area of the Proposed Development shows that there is available area on the main roofs of the new teaching block and sports centre. The proposed PV areas, taking into account spacing needed for rooftop plant equipment and the required spacing to prevent the panels from shading each other, are shown in Figure 6.

420W (~1.93m^2 in area) monocrystalline PV panels have been proposed to be installed at 30 degrees on the flat roof areas for optimal energy generation. This is summarised in Table 19.

Proposed Array (kWp)	Approximate no. Panels @420W	Active Area (m^2)	Pitch (degrees)	Orientation	Annual Generation (kWh/yr)
246.54	587	1135	30 degrees	South	199,724

Table 19 - Proposed PV Array Summary to the new buildings

[5] gshp.org.uk

Figure 6 – Proposed rooftop PV

3.5.5 Energy Storage

Although it is believed that the PV generation will not exceed usage at the site, the development could have a battery energy store linked to the PV panels which will enable building occupants to use this energy at any required time. Battery storage can also capture power from the grid and use this at times of peak demand. This means building occupants can ultimately save money since grid energy can be stored at certain times of the day when it is cheaper.

3.6 Carbon Offsetting

An energy strategy has been developed and outlined above in line with the Energy Hierarchy, and is shown to achieve and exceed the required 35% CO2 emissions offset.

The London Plan requires all 'major residential developments' to be net-zero carbon. Therefore, any residual emissions on the site created by the new buildings are required to be offset via the local Carbon Offset Fund.

The current price of CO_2 emissions in accordance with the London Plan is £95 per tonne and is calculated over a 30-year lifespan. Therefore, the required payments can be calculated with the formula below.

Carbon Offset Payment: *Residual CO_2 emissions x £95 x 30 years*

The new buildings are expected to produce 8.8 tonnes/year of CO_2 emissions; Therefore, the carbon offset payment required is £25,080 as follows:

Carbon Offset Payment: *8.8 tonnes/year x £95 x 30 years*

3.7 SEEN – In-use monitoring

The 'Be Seen' stage requires the monitoring and reporting of actual operational energy performance of major developments for at least five years.

This works to ensure the alignment of actual and estimated energy and carbon performance, as well as help identify methods for improving energy performance from the project inception stage and throughout the building's lifetime.

The reporting of energy performance data should be reported in three stages. The legal owner of the development at each reporting stage is responsible for providing the data. This is summarised in Figure 7 below:

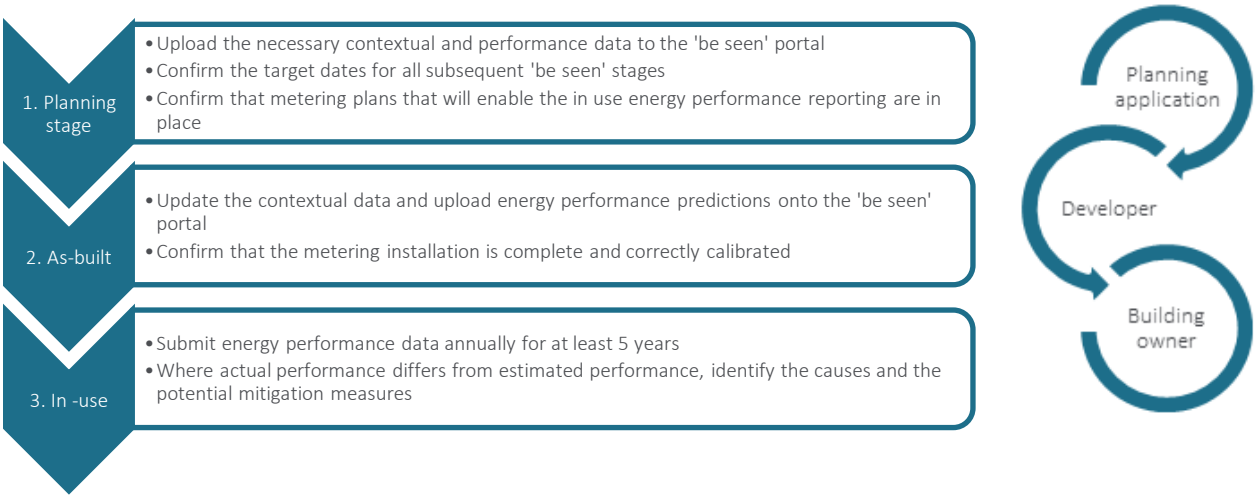


Figure 7 - 'Be Seen' process and responsibilities

At the planning stage reporting is done for the entire development as a whole, whereas at the as-built and in-use stages the development is split into a number of 'reportable units' (RUs) which applicants will need to report against individually to allow comprehensive reporting.

Third-party quality assurance mechanisms should be adopted to ensure accuracy in submissions of both predicted and measured performance. The allocation of the same person/team/organisation from design to in-use operation who will oversee the monitoring process for all different stages and who will be familiar with the intricacies of each project would be beneficial.

Accurate estimates of performer indicators (summarised below) at each stage of the process (planning, as-built, and in-use) will be provided through the 'Be Seen' reporting webforms available on the webpage of GLA website[6].

Performance indicator group	Description
Contextual data	Non-energy information such as data on location and typology/use of buildings.
Building energy use	The energy and fuel imports including data from national energy grids and district heating connections. This will enable the building owner to report on the amount of energy being consumed.

[6] 'Be seen' energy monitoring guidance | London City Hall

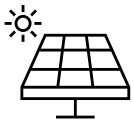
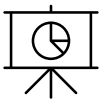
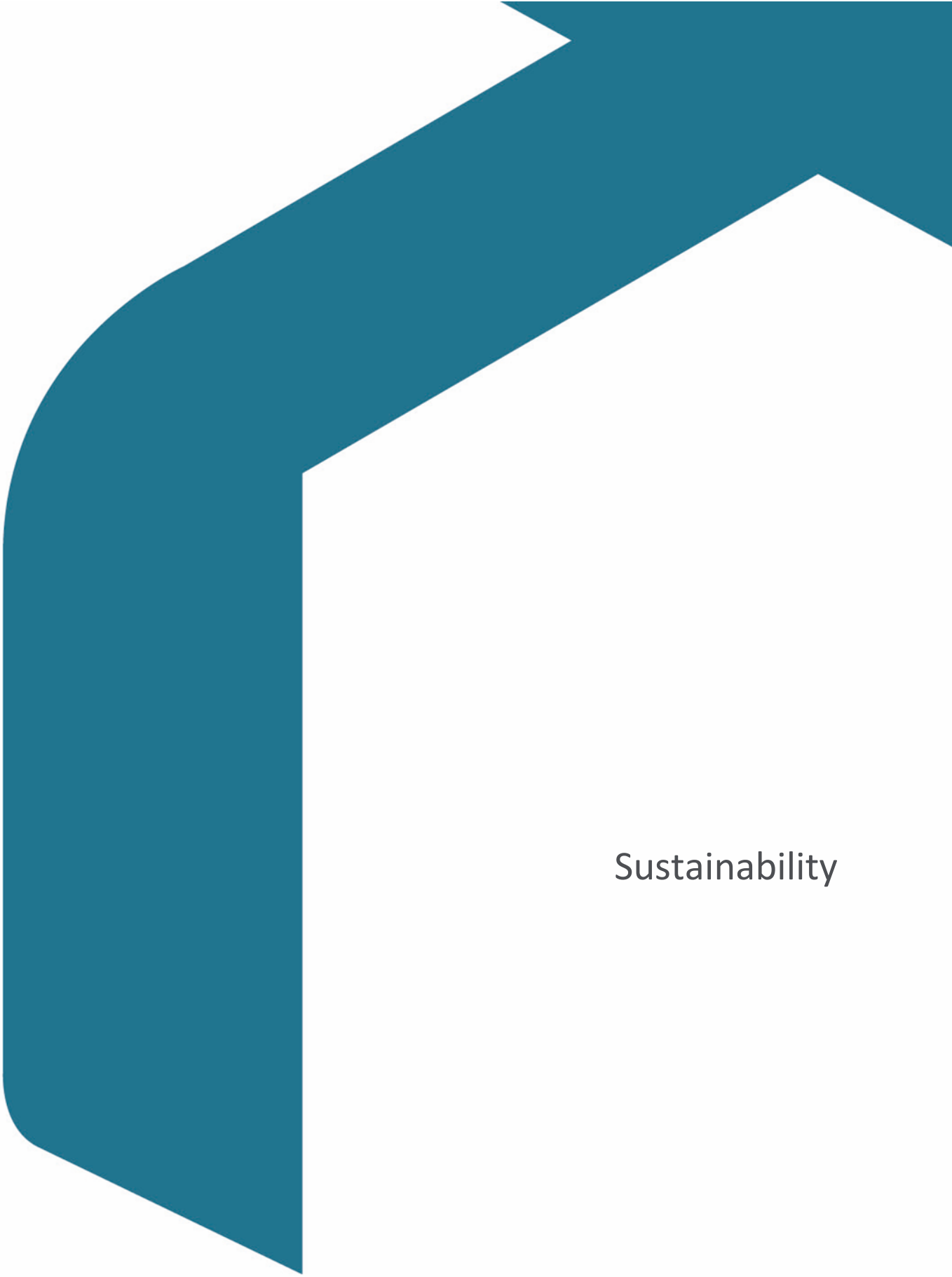
 Renewable energy	The renewable energy generation within the development will identify how much energy is being generated on-site and where this is used.
 Energy storage equipment	Data on the building's energy storage equipment
 Plant parameters	The performance of heat or cooling generation plant within energy centres that form part of a development.
 Carbon emissions	The development's estimated carbon emissions at planning stage based on the appropriate carbon emission factors, as set out in the GLA's Energy Assessment Guidance. When on-site carbon reductions have been maximised, but a carbon shortfall still exists, the carbon offsetting contribution to the relevant local authority's fund should be reported.

Table 20 - Be Seen' Performance indicator groups

The Proposed Development will be supplied with Smart Meters and a building energy management system (BEMS) along with associated internal energy displays. This will further improve energy efficiency by allowing building managers/occupants to observe their energy use in 'real time' and manage it more effectively.



Sustainability

4.0 Sustainability

The World Commission on Environment and Development (WCED) report: Our Common Future, describes Sustainable Development as development that:

"meets the needs of the present without compromising the ability of future generations to meet their own needs."

4.1 Environmental Assessment

LBRuT Sustainable Construction Checklist

The London Borough of Richmond upon Thames (LBRuT) Sustainable Construction Checklist has been developed by LBRuT, and is supplemented by the Sustainable Construction Checklist SPD.

The checklist *"forms part of the assessment for planning applications for new build, conversion and retrofit properties within the London Borough of Richmond upon Thames…… The aim of this Checklist is to engage and inform developers on sustainability issues relevant to their development. This will enable all building works to make an increased contribution towards local sustainability and help create a townscape which will adapt to climate change as well as mitigate its effects. Overall, measures will be implemented towards improving cost efficiency of our buildings, minimising environmental impact, and improving quality of life for all of those in the Borough of Richmond."*

The Checklist forms a mandatory part of the planning application for the following classes of development:

- *All new residential development providing* ***1 or more new dwellings****, including conversions and extensions that create one or more new dwellings.*
- *All new non-residential development including conversions providing* ***100m² or more floor area****, including extensions over 100m²"*[7]

A Sustainable Construction Checklist has been completed for the Proposed Development showing a score of 71.5. The full checklist can be viewed within Appendix CE.

4.2 Pollution

Air

The Proposed Development will aim to limit its contribution to local air pollution by installing heating and hot water systems which emit no onsite NO_X emissions, in addition to the installation of PV. The communal heat pumps proposed for both the new and existing buildings consume grid electricity (when not consuming electricity generated by the PV). As the NO_X emissions resulting from the production of electricity decreases at the national scale, the resulting theoretical emissions from the Proposed Development will do also. Furthermore, the use of PV panels will decrease the import of electricity from the national grid and replace it with PV electricity which produces no emissions during operation.

The Proposed Development is located within a medium to high NO_X emissions area as defined by the UK NO_X emissions map, see Figure 8. Internal pollution levels will be reduced through the use of MVHR with filtered intakes.

[7] London Borough of Richmond upon Thames – Sustainable Construction Checklist SPD (June 2020)

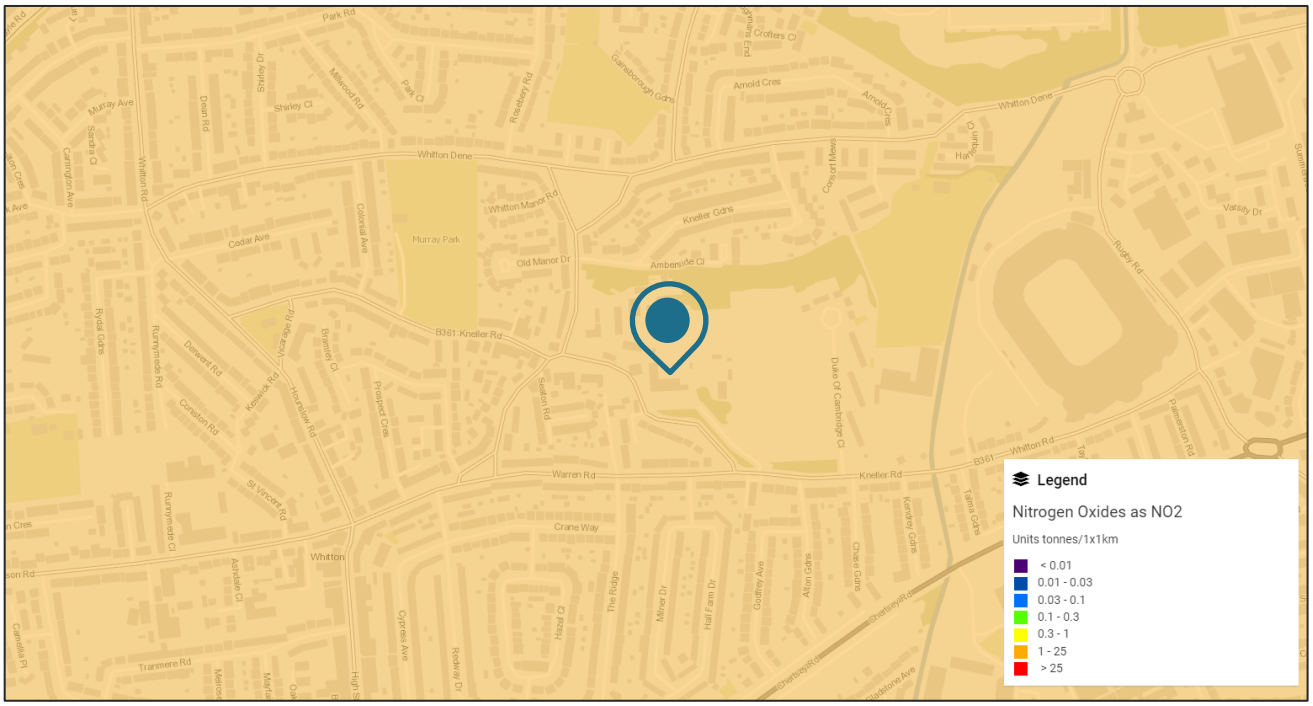


Figure 8 - UK Air Pollution Map showing pollution from Nitrogen Oxides as NO2 (https://naei.beis.gov.uk/emissionsapp/)

Noise

The Proposed Development is located in a residential setting and is on the site of an existing educational use development. Any plant installed will be located in a position to minimise noise disturbance and shielded to prevent potential noise disturbances. Acoustic enclosures are recommended for the ASHP units to avoid disturbance to the building occupants within the Proposed Development and residents of surrounding dwellings.

An Acoustic Report for planning has been undertaken by Cundall, which has been submitted with the application and confirms that the proposed use of the outside sports pitches, with the mitigation measures recommended, will not entail an adverse noise impact on surrounding noise sensitive receptors. Cundall's Acoustic Planning Report confirms that with the noise controls recommended in their report, the Council's noise requirement for new mechanical plant units will be met. Furthermore, the Proposed Development will be a highly insulated building with excellent air-tightness which should limit any noise from inside the building far below that of the existing.

The Proposed Development provides limited on-site car parking, instead encouraging staff and pupils to use public transport and sustainable transport methods – such as cycling - rather than personal vehicles which will avoid any increased noise impact which may have resulted from increased transportation. A School Travel Plan will be secured as part of the planning permission, to promote sustainable travel.

Light

The design and layout of the site for practical use has been considered while trying to maximise internal daylight levels, in addition to maintaining a visual style in line with the Site's heritage significance.

All main occupied spaces have glazing (windows or roof lights) to provide natural daylight, and light-coloured curtains or roller blinds will be provided to enable glare control, privacy, and reduce overheating potential.

Light Pollution will be minimised where possible through the careful specification and positioning of external lighting around the Proposed Development, ensuring minimal light pollution from the site. Special attention will be given to security lighting (where fitted) to ensure it is appropriately focussed and controlled.

All external space lighting will be provided through low energy fittings, with security lighting being PIR and daylight/timer controlled. Any external signage, where installed and lit, will be installed and controlled in line with best practice.

An external lighting report prepared by Cundall forms part of the planning application, and the external lighting strategy has been arrived at following engagement with the project's ecologist and an assessment of the site characteristics and designations.

4.3 Flood Risk

The selected site is at very low risk of flooding from rivers and seas (Figure 9) and while the surrounding area has several roads shown as at high risk of flooding from surface water, the roads adjacent are mainly very low and low risk, with a very small portion of the road at medium risk. The actual site is not shown as at risk of flooding from surface water (Figure 10).

A Flood Risk Assessment has been prepared by RPS, which forms part of the planning application and a Drainage Strategy has been developed by AKS Ward; which includes sustainable urban drainage systems (SuDS) including permeable paving, green roofs, a swale and soakaway.

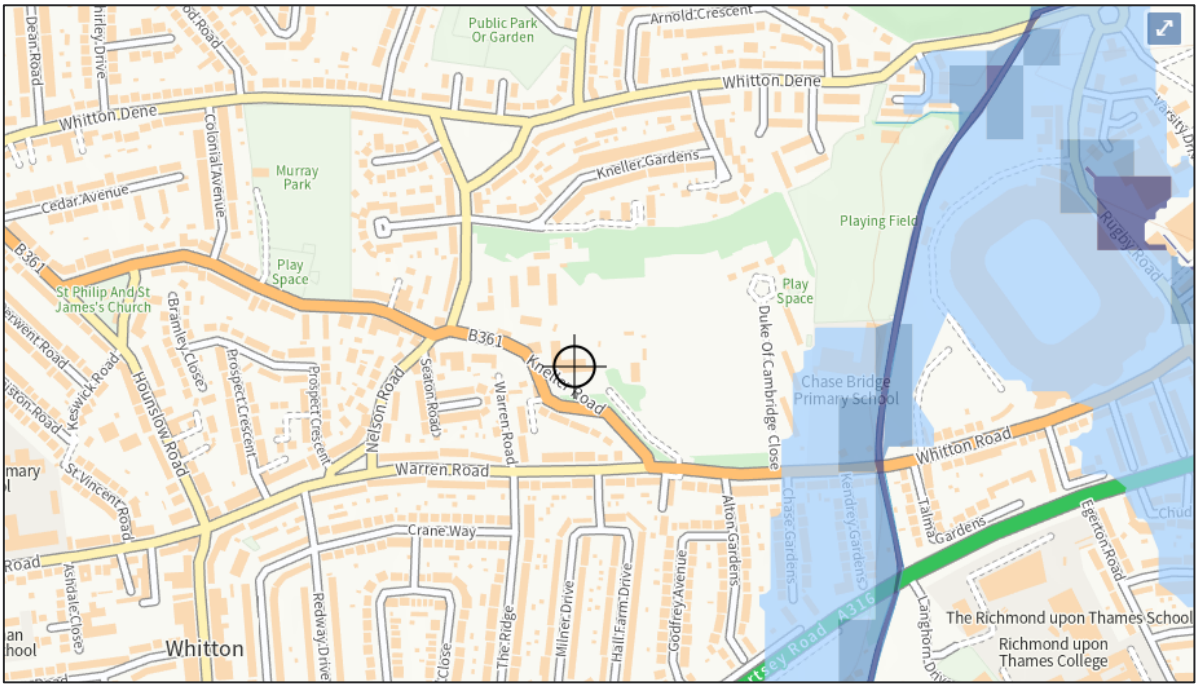


Figure 9 - Flood map showing risk of flooding from rivers or the sea (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map)

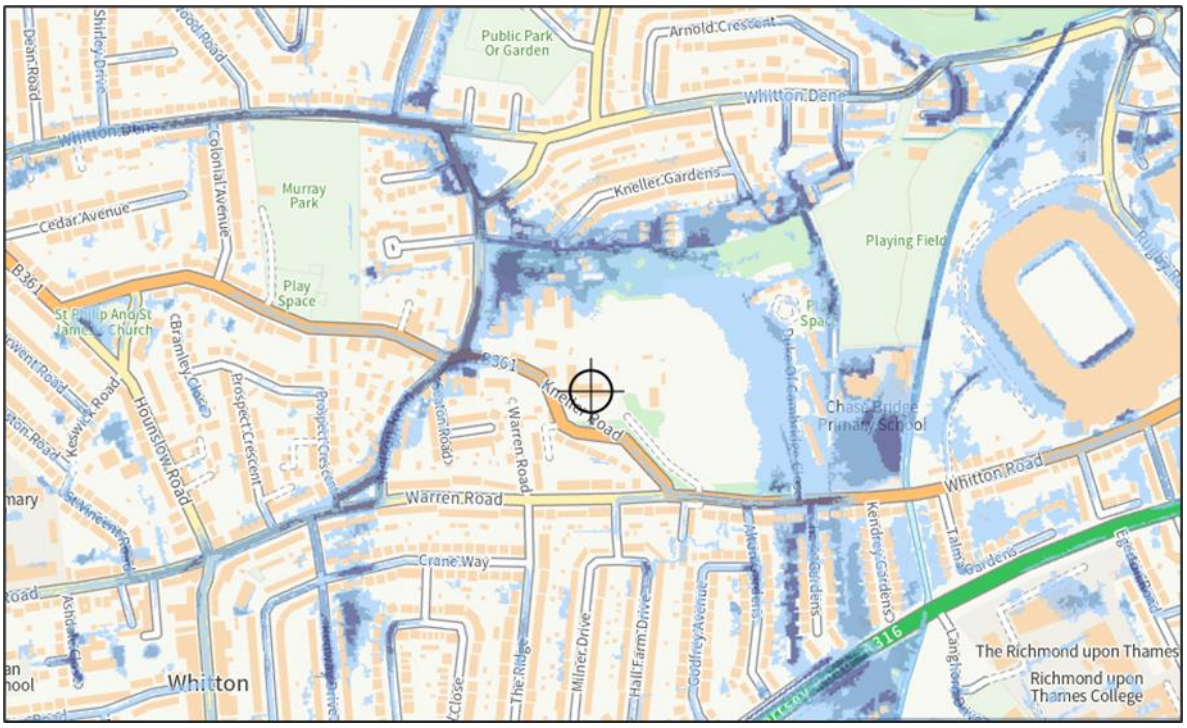


Figure 10 - Flood map showing risk of flooding from surface water (https://flood-warning-information.service.gov.uk/long-term-flood-risk/map)

4.4 Transport

The Proposed Development is within a good area for public transport, within PTAL Zone 2. A Transport Assessment and School Travel Plan, for both staff and pupils, will be included as part of the Application Documentation.

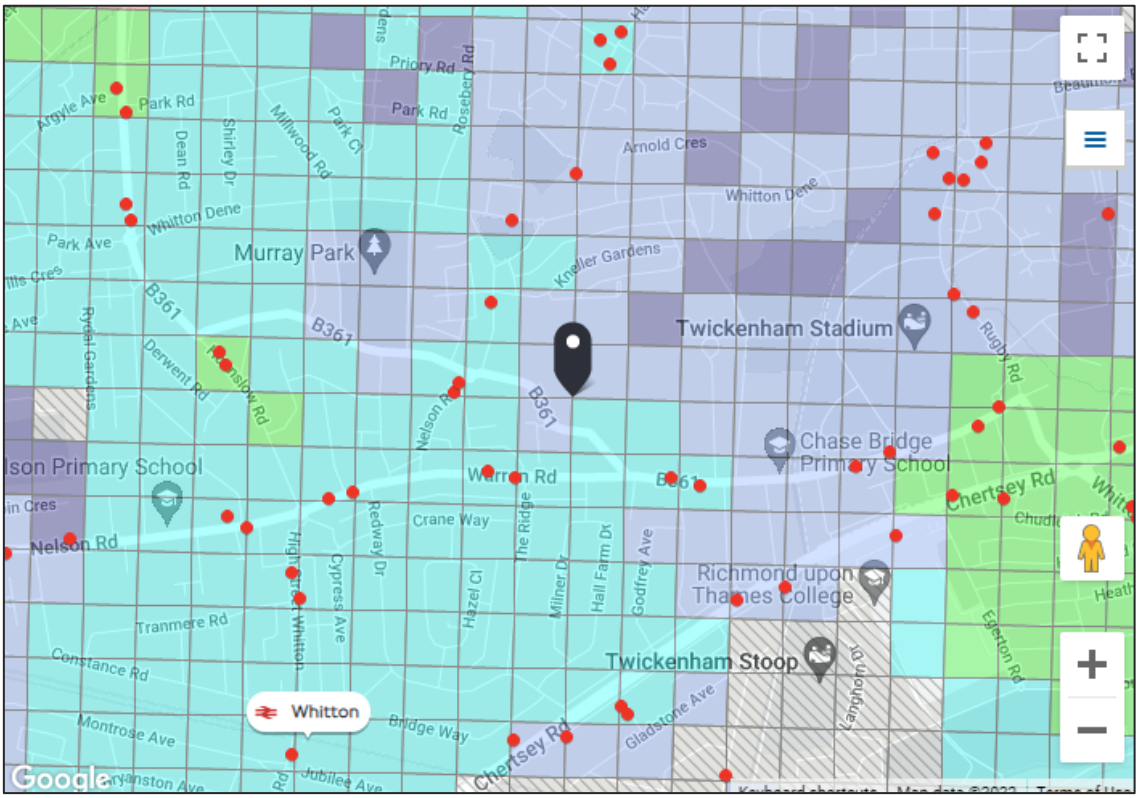


Figure 11 - PTAL output for Base Year (https://tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-webcat/webcat)

Public Transport

The site has multiple bus stops in the surrounding area such as Kneller Hall, and Nelson Road Bus stops with links throughout the local area and connections to the wider bus network through local hubs at Richmond Railway Station. Please see the submitted Transport Assessment for further details.

The school will operate a number of school bus routes in the morning and at the end of the day. This will reduce parent drop-offs at the site.

Parking

A total of 43 car parking spaces will be provided on site. Of these 7 will be disabled bays. The parking on site is for staff who will be allocated an onsite bay. All other staff will be required to travel to site by public transport.

Electric Vehicle Charging

As per the sustainable construction checklist outlined by the local planning policy, 1 in 5 (20%) of parking spaces will provide an active electrical charging point. 8 no. EV charging points is has currently been proposed. All other spaces will have a passive electric charging provision.

Cycle Storage

The Proposed Development will allow space for multiple cycle storage locations within the grounds, including 144 allocated for pupils, 28 for staff, and 10 for short stay. These will be suitably covered and allow the bikes to be secured in a manner that secures both the frame and the wheel using a conventional cycle lock.

4.5 Biodiversity

Biodiversity is generally considered to be the variety of life forms within a certain ecosystem. The current site conditions consist of buildings, hard standing and extensive soft landscaping including woodland, grassed playing pitches, and a variety of grass types. There are scattered trees throughout the site, mostly associated with hardstanding walkways, and beech hedgerows separating sections of the site. To the east of the site there is a large amenity grassland sports field with an area of scattered trees on improved grassland bordering the north. An area of woodland extends just east, outside the site boundary.

Landscaping will be undertaken to the Proposed Development to include outdoor courtyard, a melon yard and garden area, an informal hard social area, and a variety of new planting. Some trees will also be removed subject to a Preliminary Bat Roost Assessment. The majority of new planting will be of a native species type where possible to provide additional habitat for local wildlife species and planting that can cope with water stress (i.e. no irrigation systems). Green Roofs are also provided on the flat roofs of the teaching block and sports centre, with additional wildlife planting and trees. The combination of these measures will contribute to the enhancement of the overall site biodiversity, and that of the surrounding environment. Through the extensive landscaping scheme, a net gain in biodiversity will be achieved on site.

Urban Greening Factor

Urban Greening is a process of providing additional green spaces, planting and grassland within an urban environment in order to achieve net biodiversity gain. The addition of ‘green’ elements within a town or city will assist with urban cooling through evaporative cooling and the shading of concrete and other building materials that contribute to the urban heat island effect. Urban Greening also results in a more natural water cycle, where vegetation is used to intercept and slow down water, thus reducing the risk of localised flash flooding. In addition, this can help improve the local air quality, with vegetation absorbing gaseous pollutants and releasing oxygen into the environment.

An Urban Greening factor can be applied to a site based on the proposed makeup of the development, with benchmarks set as to which score is required by the site.

In Line with the New London Plan policy G5, a calculation based on the guidance for Greater London Authority has been undertaken to give an indication of the Proposed Development's impact on urban greening.

Current calculations show that the proposed measures in the Proposed Development result in an Urban Greening Factor of 0.8 which exceed the GLA benchmark of 0.3. The calculations can be viewed in Appendix F.

4.6 Resource efficiency

Construction Phase Waste Management

The Proposed Development will aim to minimise the waste produced from the site during the construction phase.

A comprehensive Construction Management Plan will be implemented from the outset of site works and will meet the BREEAM requirements for waste management and will follow the principles of the waste hierarchy.

The construction waste generated as part of the redevelopment will be segregated and monitored in accordance with best practice, with suitable materials being recycled as part of this process, either to be reused on site or introduced back into the supply chain through recycling by a Licensed Contractor, therefore minimising the amount of waste being disposed of in landfill sites.

It is estimated that approximately 25% of the demolition waste will be able to be re-used on site, with the remainder taken offsite for processing. It is expected that, in total, a minimum of 85% of the waste arising from the site will be diverted from landfill.

Reusing materials on site (retained façade) will reduce the embodied energy of the development through the reuse of the energy that exists in that material. Transportation of new material to the site will be reduced, reducing the CO_2 emissions associated with transportation and material manufacture.

Where waste will need to be disposed of, this will be done in line with the Waste Hierarchy, with as much as practicable being recycled, and the remainder being dealt with through a specialist waste recycling contractor. Nominal construction waste should be sent to landfill or for incineration unless this is unavoidable due to the materials found on the existing site.

Resource Management

Policies will be put in place for management of site impacts such as air and water pollution in line with industry best practice. Monitoring and reporting on carbon emissions and water use from site related activities will take place in line with national benchmarks.

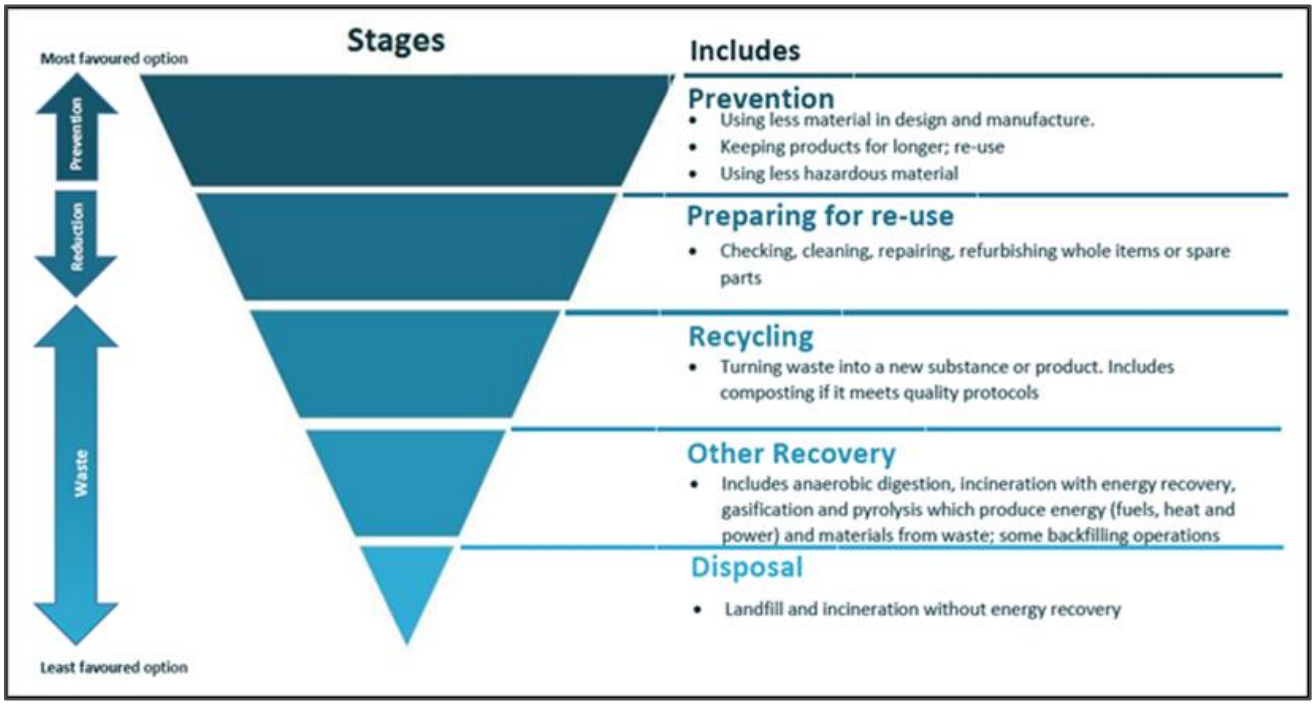


Figure 12 - The waste hierarchy

The overall management of the construction waste will be monitored through the Considerate Constructors Scheme as part of Best Practice Site Management.

Materials

The Proposed Development is to use high quality, low impact materials in order to minimise the overall impact on the environment as far as possible.

The form of construction is anticipated to be timber frame construction for the sports pavilion, and steel frame construction for the other new buildings. Elements of the existing structure will be retained for the listed building elements.

All timber materials for finishing elements will be sourced from FSC and/or PEFC sources and all other materials sourced from suppliers who have an accredited Environmental Management System (EMS) (ISO14001, BS8555 or BES6001) for the extraction and process stages of the material manufacturing, ensuring that any environmental impact caused by the building materials is analysed and mitigated where possible.

All timber and timber-based products use on-site will be legally sourced with appropriate Chain of Custody certification to confirm this.

As standard industry best-practice, all insulation on the site will have an Ozone Depletion Potential (ODP) of zero, and a Global Warming Potential (GWP) of <5, further minimising the Proposed Developments effect on global Climate Change.

Water

Areas of the Southeast of England, particularly Greater London, have been declared areas of 'serious water stress'. Water is a vital resource and efficient usage should be encouraged in all new buildings. The Proposed Development aims to significantly reduce mains water use through a combination of efficiency measures, including the use of fittings with a low capacity or flow restrictors to reduce water use and PIR sensors linked to water shut-offs valves to reduce the chances of water waste.

Internal water use will be reduced in line with Building Regulations Part G and BREEAM NC 2018 Wat 01 to reduce incidences of water stress at times of peak demand, and/or minimal supply:

The specification outlined below sets out the maximum flow rates that can be fitted to individual components to meet these requirements:

- WCs: 3.75 litres effective flush volume
- Wash-hand basin taps: 3.75 litres/minute
- Kitchenette taps: 6 litres/minute
- Kitchen taps (restaurant, pre-rinse nozzles only): 6 litres/minute
- Showers: 6 litres/minute
- Urinal (2 or more): 1.5 litres/bowl/hour
- Urinal (1 urinal only): 2 litres/bowl/hour
- Greywater and rainwater system: 25% of WC or urinal flushing demand met using recycled non-potable water
- Baths: Max. 140 litres to overflow
- Domestic sized washing machines: 40 litres/use
- Commercial or industrial sized washing machines: 7.5 litres/kg
- Domestic sized dishwashers: 12 litres/cycle
- Commercial sized dishwashers : 5 litres/rack
- Waste disposal unit: 0 litres/minute

Passive Design Analysis

5.0 Passive Design Measures

A passive design analysis has been carried out for the new buildings in the Proposed Development. A range of passive design measures have been incorporated in the building design and will be discussed in this section. These include the building orientation, glazing layout and size, solar control glass, daylight harvesting and shading devices. These passive design measures, when used in combination with active design measures - including energy efficient lighting and MVHR - will aim to deliver low energy, low carbon emissions and low operational costs. The passive design measures that have been Through the use of passive design measures, a total energy demand of 9.05 MJ/m²/yr and 0.58 kgCO_2/m²/year is offset compared to that with notional design specifications.

5.1 Site location

The Site is located on Kneller Road, in Whitton, in close proximity to Twickenham Stadium. Outside the site boundary, houses are predominantly semidetached or terraced from the inter-war period. The area is characterised by large front gardens, now converted to off-street parking, tree lined streets and generous rear gardens.

5.2 Site weather

The overall climate of the London, UK does not vary greatly. The UK climate is classified as temperate (C), without a dry season (f), with a warm summer (b) – 'Cfb' - by the Köppen climate classification scheme. This temperate region has the coldest months averaging between 3°C and 8°C and at least one month averaging above 10°C. The summers are comfortable; the winters are long, very cold, and windy; and it is partly cloudy year-round. Over the course of the year, the temperature typically varies from 3°C to 21°C and is rarely below -2°C or above 25°C.

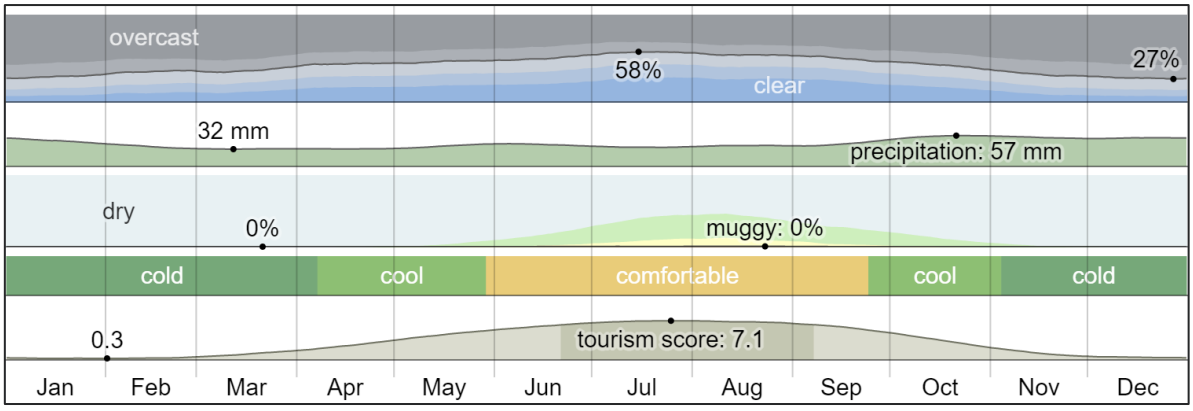


Figure 13 - Climate summary – Twickenham, UK (weatherspark.com)

The warmest months on average are July and August, which see the highest average maximum (Figure 14) and minimum (Figure 15) temperatures, while December, January and February are the coldest months with the lowest maximum and minimum temperatures.

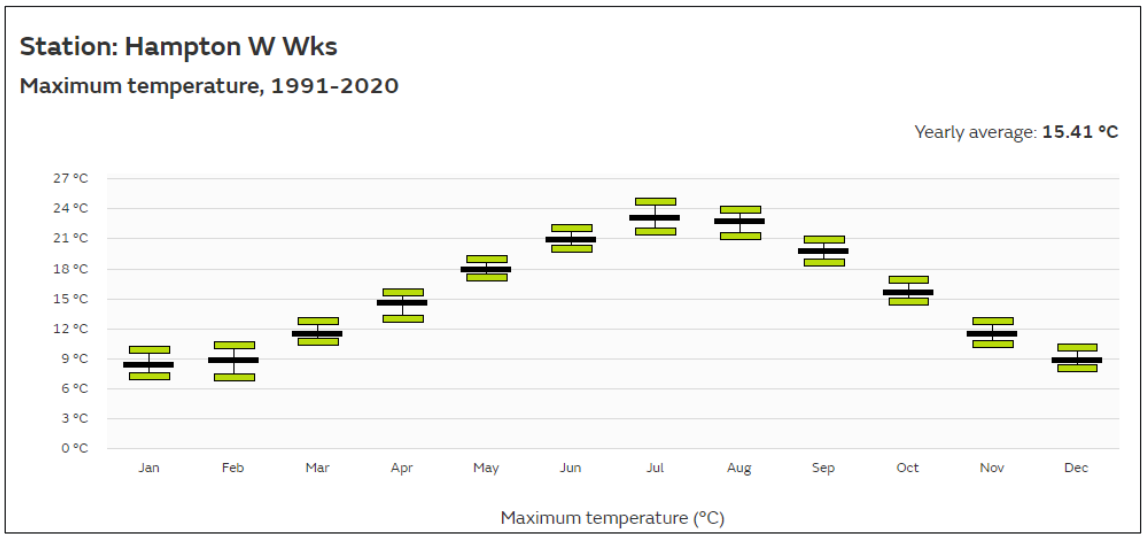


Figure 14 - Average maximum temperature 1981-2020 – on avg. 1 in 5 years, 80th and 20th percentile – Hampton W Wks, UK (metoffice.gov.uk)

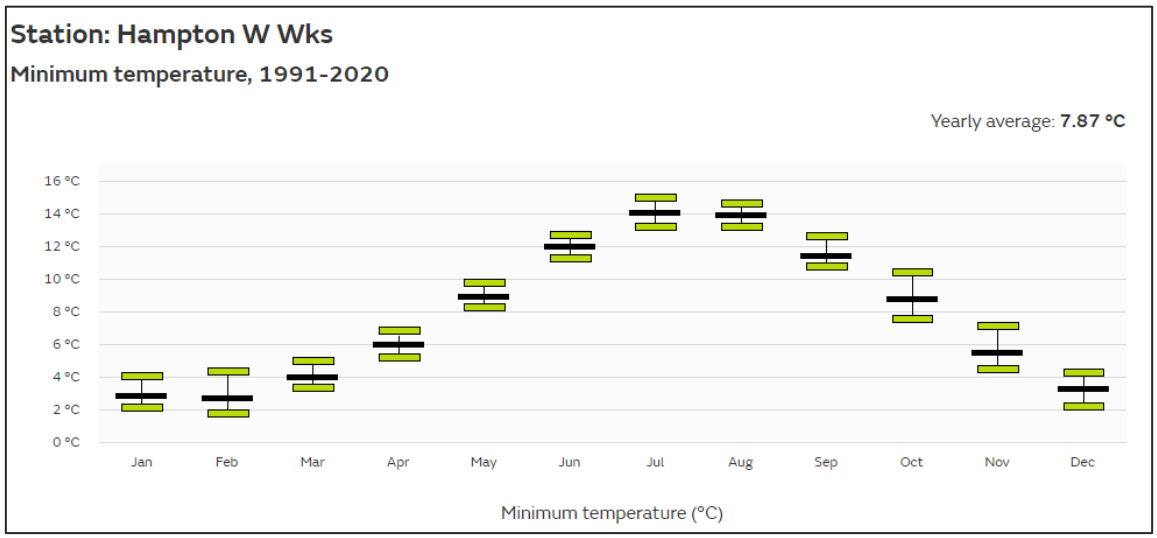


Figure 15 - Average minimum temperature 1981-2020 - on avg. 1 in 5 years, 80th and 20th percentile – Hampton W Wks, UK (metoffice.gov.uk)

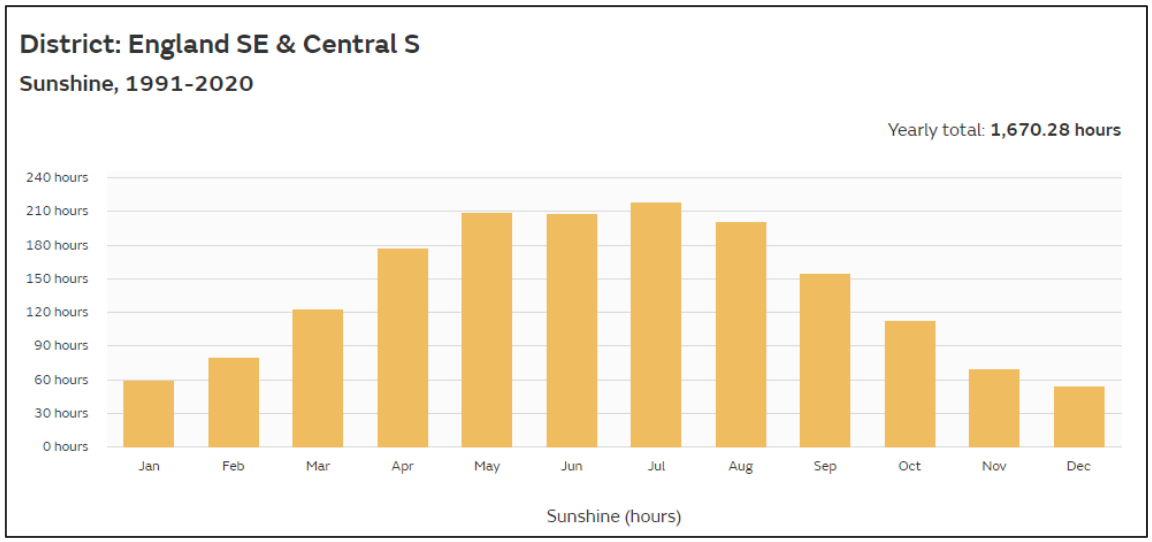


Figure 16 - Average sunshine hours - South East and Central South, England (metoffice.gov.uk)

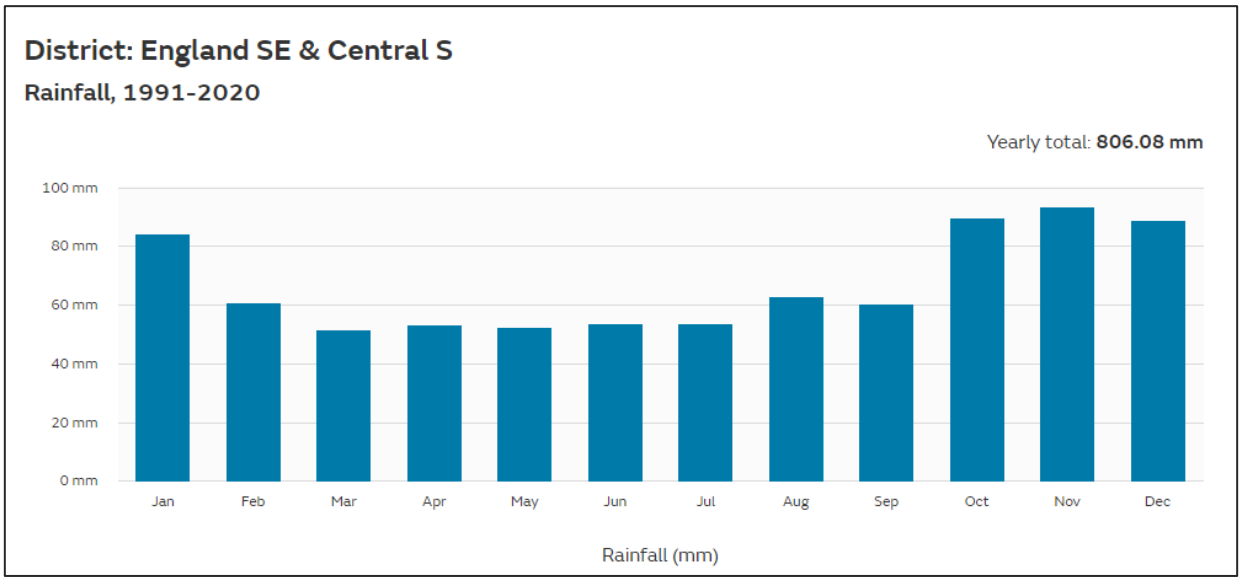


Figure 17 - Average rainfall - South East and Central South, England (metoffice.gov.uk)

Sunshine hours provide an indication of cloudiness vs sunshine hours. The South East and Central South England data shows that the Proposed Development will receive a yearly average of 1,670 hours of sunshine each year. This is higher than the UK average of 1,373 hours. July sees the most sunshine hours, averaging over 6.5 hours per day, while December sees the fewest, averaging just over 1.5 hours per day.

The South East and Central South England data shows that the Proposed Development will receive yearly average rainfall of 806 mm per year, which is lower than the UK average of 1,149.5 mm per year. The significantly lower rainfall than the UK average, coupled with the high population density of the area contributes to the regional water stress.

5.3 Microclimate

An understanding of the characteristics of the urban microclimates allows Architects and Developers to make informed strategic design decisions with respect to not only the climatic impacts of their buildings, but also the effect of the resulting microclimatic variables on the performance of buildings. Particularly, the urban microclimates that will affect passive and low energy designs and the use of renewable technologies in urban areas.

The urban wind and solar radiation data along with sun path diagram can be used for developing better design options for renewable energy technologies and passive solar design within the urban environment.

The sun path diagram[8] plots the sun's elevation angle and azimuth angle over a day as seen from a given location which can be used to roughly account for shading from surrounding objects of a site including trees by incorporating shading masks.

[8] For detailed explanation on how to read sun path chart go to - http://solardat.uoregon.edu/AboutSunCharts.html

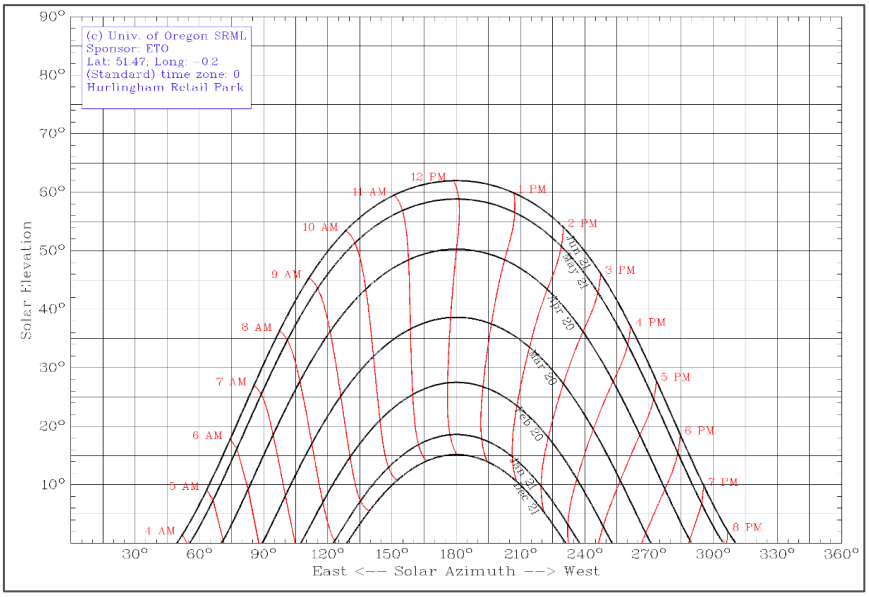


Figure 18 – Sun path diagram for the site (solardat.uoregon.edu)

Figure 19 shows the predominant wind direction is from the west, and Figure 20 shows the average wind speeds vary between 21.5 kilometres per hour (kph) in January to 15.5kph in July/August.

The average hourly wind speed in Twickenham experiences significant seasonal variation over the course of the year. The windier part of the year lasts for 5.7 months, from 12 October to 2 April, with average wind speeds of more than 18.5 kph. The calmer time of year lasts for 6.3 months, from 2 April to 12 October, the calmest month of the year being July, with an average hourly wind speed of 15.9 kph.

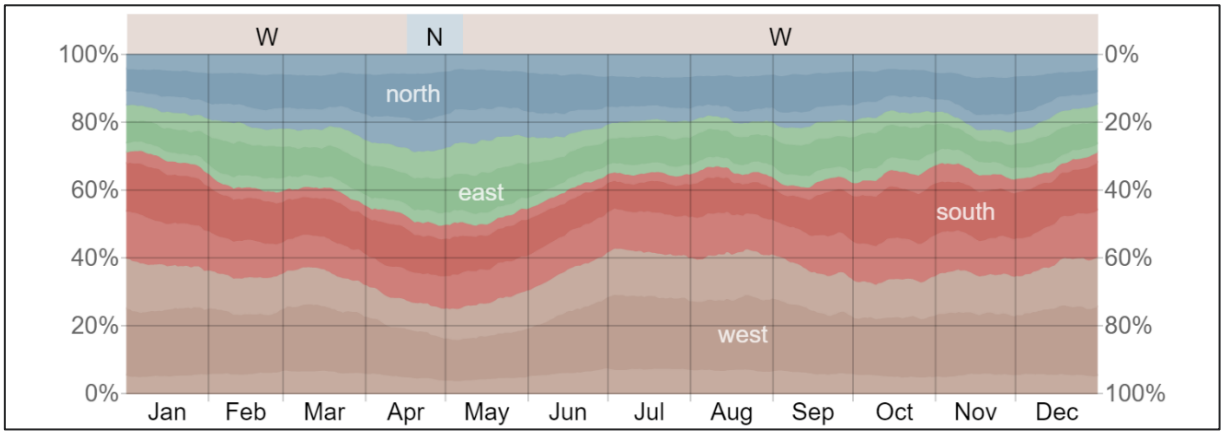


Figure 19 - Average wind direction (percentage of hours above 1.6kph), Twickenham, UK (weatherspark.com)

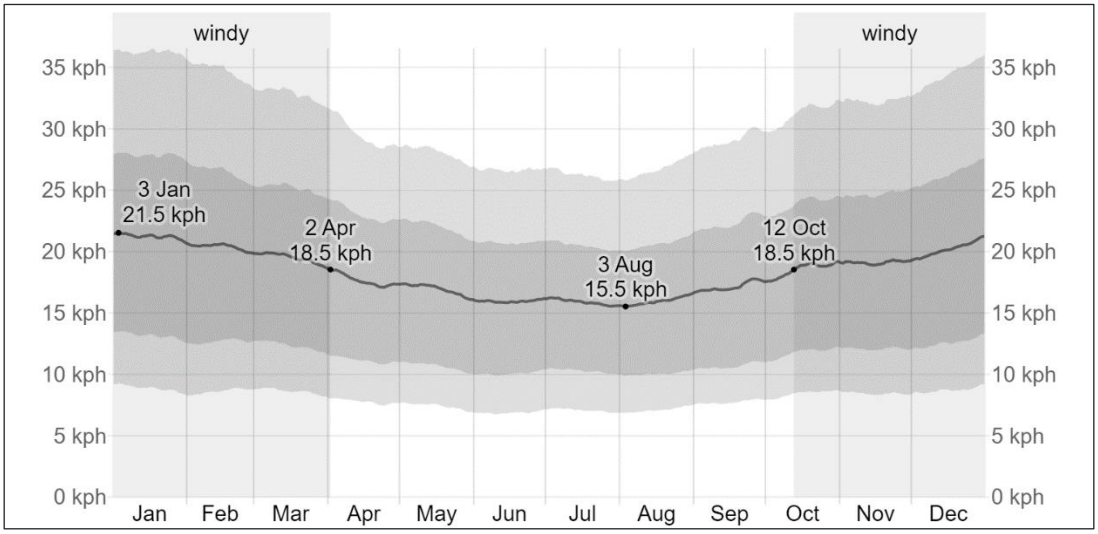


Figure 20 - Average wind speed – Twickenham, UK (weatherspark.com)

The Site is located on Kneller Road, in Whitton, in close proximity to Twickenham Stadium, with a number of more modern buildings distributed across the site. To the east, a large open space includes playing fields and tennis courts. Outside the site boundary, houses are predominantly low-rise semidetached or terraced. The wind acceleration and solar shading caused by the surrounding built environment will therefore be minimal.

The south side of the development is exposed to useful solar gains in the winter months but could be at risk of overheating during summer months without appropriate solar control measures.

The Proposed Development is approximately 20m from the nearest surrounding buildings. Therefore, the surrounding buildings will have minimal impact in terms of overshadowing and will not limit the available solar radiation.

5.4 Building layout, orientation and form

The buildings have been positioned within the site to maximise the usable space, both for the internal and external spaces. They have been designed to allow easy flow and access within the main entrances and the main occupied zones in the new buildings, as well as between buildings within the site.

The proposed new buildings are positioned with a North-South orientation to maximise solar gain where this is possible within the site boundaries. The design will maximise natural light and positive solar gains with glazing on the south, east and west elevations. Natural ventilation will also be provided through openable windows which will give purge ventilation to the buildings which will balance the overheating risks. All glazed areas of the building will have elements of shading provided by the building form or internal curtains.

The Proposed Development is such that the main elevations are consistent with the existing listed main Kneller Hall building, guards house and school hall.

5.5 Building fabric

The construction method will most likely be of timber frame construction for the sports pavilion, and steel frame construction for the other new buildings. All elements of the thermal envelope will have some form of insulation fitted to reduce the heating requirement throughout the year, while maintaining the required constant temperature for the occupants. A design infiltration rate of 5m^3/hr/m^2 has been targeted to help reduce the building's heating requirement but a lower target than this is recommended to further reduce heating load[9].

[9] Although the worst acceptable standard is 10 (m^3/hr/m^2) the Notional building target is 3 (m^3/hr/m^2).

Element	Proposed Building (U-value)
External Walls	0.14
Exposed Floor	0.10
Exposed Roof	0.10-0.12
Windows and Rooflights	0.80 (g-value 0.30, LT 71%)
External Doors	1.20
Air Tightness @ 50 N/m^2	3 (m^3/hr/m^2)

Table 21 - Fabric energy efficiencies

5.6 Thermal mass

The overall building should have a low thermal mass as construction will most likely be of steel frame and timber frame construction. A low thermal mass will provide high energy efficiency but increase the risk of overheating during the summer months when the mass is not exposed due to lightweight non-load bearing building fabric. Exposed mass is proposed for the internal ceilings of the new teaching block, leaving the services and structure exposed with open ceiling/plenums and therefore increasing the thermal mass. This will help with reducing the overheating risk. An overheating assessment of the new teaching block has been conducted, results indicating that the assessed occupied spaces pass the assessment under the current weather file. This is further discussed in Section 7.0.

5.7 Building occupancy type

The proposed new buildings consist of an education facility (teaching block), a new sports centre consisting of a sports hall, swimming pool, and fitness studio, as well as a sports pavilion providing WCs and changing room facilities. A new extension to the main Kneller Hall building has also been proposed to provide a library and learning space. Whereas an extension to the school hall building has been proposed to include lobby area, associated WCs, dressing rooms, and a breakout space. All buildings have been designed with access corridors and amenities for the size and functionality of the building type.

5.8 Daylighting strategy

The proposed new buildings are designed to maximise natural light and positive solar gains with glazing on the south, east and west elevations. The new teaching block will have large glazed areas to maximise natural daylight and enhance the building occupants' wellbeing, with overhangs suitably fitted to control daylight and glare. The installation of daylight sensors with appropriate zoning will allow natural daylight to be harvested and maximised throughout the day, thereby reducing the need for artificial lighting. This will help reduce the energy use and subsequent carbon emissions of the site. An internal daylight analysis has been carried out for the new teaching block, results which indicate sufficient daylight levels can be achieved. This is further discussed in Section 6.0 of the report.

5.9 Ventilation strategy

In modern air-tight buildings, careful consideration needs to be given to the specification of ventilation systems to remove moisture and meet minimum ventilation standards in line with Building Regulations requirement, ensuring a healthy internal air quality for building occupants.

Natural ventilation will be provided through openable windows to all main occupied spaces and circulation areas. Mechanical ventilation with heat recovery will also be provided to selected occupied spaces to provide supply and extract of air to ensure adequate ventilation levels area achieved. Standard extracts are also provided to kitchens and WCs.

5.10 Passive Design Modelling - Principles, Measures and Results

The implemented measures and results of the simulation are summarised in the tables below.

The passive design analysis has been calculated using IES VE DSM Level 5 software. To enable a baseline for comparison, a 'standard building' was modelled to be compared with the proposed design i.e. the 'proposed building'. The 'standard building' was modelled with fabric performance, glazing area, internal gains exactly as per an equivalent Building Regulations Volume 2 'notional building'[10]. The below lists the similarities and differences between the modelled 'standard building' and 'proposed building'.

Element	Standard Building (U-value)	Proposed Building (U-value)
External Walls	0.19	0.14
Ground Floor	0.16	0.10
Roof	0.15	0.10-0.12
Rooflight	2.10	0.80
Doors	1.90	0.80-1.20
Air Tightness @ 50 N/m^2	3 (m^3/hr/m^2)	3 (m^3/hr/m^2)
Thermal Mass	Lightweight construction below 137.5 kJ/m2K	Lightweight construction below 137.5 kJ/m2K
Ventilation	MVHR with notional efficiencies	MVHR with 80% heat recovery efficiency
Daylighting	Daylight dimming without back-sensor control	Daylight zoning and sensors
Internal Gains	Occupancy, equipment and lighting heat gains as per notional building for building type D1 and D2	Occupancy, equipment and lighting heat gains as per notional building for building type D1 and D2[11]
Glazing area	40% of exposed façade area	As per proposed design

Table 22 – Standard Building vs Proposed Building inputs

[10] The 'notional building' has the exact size, shape, orientation of the proposed design but is based on Part L Volume 2 notional fabric performance, internal gains, ventilation and daylighting strategy. The specifications are outlined in Approved Document L 2021 Volume 2 and the Non-Domestic Building Services Compliance Guide.

[11] Building type D1: Primary or secondary school (Secondary); Building type D2: General Assembly and Leisure (Sports Centre)

Design Measures	Standard Building	Proposed Building
External shading devices	None based on notional building	Overhang fitted where proposed
Fabric Performance	As per notional building	As per Table 22 – the proposed design
Window size and location	As per notional building	As per proposed design, glazing maximised on the east, west, and south facades
Thermal mass	Lightweight construction below 137.5 kJ/m2K	Lightweight construction below 137.5 kJ/m2K
Daylighting strategy	Daylight harvesting via zoning and sensors	Daylight harvesting via zoning and sensors
Ventilation strategy	MVHR	MVHR

Table 23 – Standard Building vs Notional Building implemented passive design measures

The proposed building design with passive design measures as listed in the above table has a total site-wide energy demand[12] of 90.58 MJ/m² compared to 99.63 MJ/m² of that of the 'standard building'. Thereby the reduced total energy demand and carbon dioxide (CO_2-eq) emissions[13] resulting from the passive design measures (as listed in Table 23) are 9.05 MJ/m^2 and 0.58 kgCO_2/m^2 respectively.

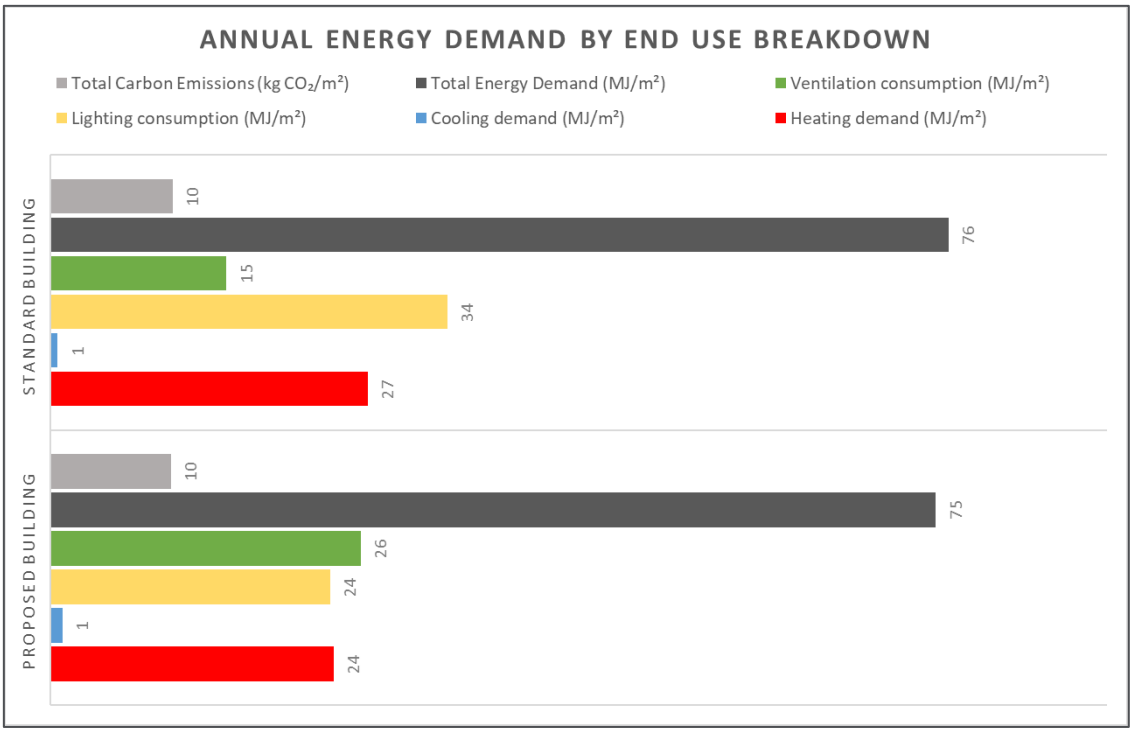


Figure 21 – Annual Energy Demand – Baseline (Standard Building) vs Proposed design (Proposed New Developments)

[12] Total energy demand excludes Hot Water load.
[13] Carbon factor for electricity based on SAP 10.2 figure of 0.136 kg of CO_2e per kWh.

5.11 Adaptation to climate change

The proposed low thermal mass and highly insulated thermal envelope will provide little protection from fluctuations in short-term outside temperature, including extreme weather events. But the provision of MVHR will provide efficient control of the indoor thermal environment which is important for health and wellbeing.

A full overheating analysis compliant with CIBSE TM52 has been undertaken as part of the BREEAM Ene04 criterion 1 requirement. This is further discussed in Section 0, the results which suggest that thermally comfortable conditions can be expected under current weather conditions.

A BREEAM compliant flood risk assessment has already been carried out which details the site's approach to flood risk and drainage strategies for 1-year and 100-year return period events, accounting for any projected changes in precipitation and future flood risk as a result of climate change.

5.12 BREEAM NC 2018 Ene04 – Requirement Justifications

This section illustrates compliance with the various requirements of BREEAM NC 2018 Ene04 in relation to this analysis to confirm the achieved credits for the new buildings of the Proposed Development. Issue Ene04 Low Carbon Design of BREEAM NC 2018 weighs three number of credits and is split into two parts.

- Passive design (two credits)
- Low and zero carbon technologies (one credit)

5.12.1 One credit – Passive design analysis

Criterion 1: Hea 04 Thermal comfort: The first credit of Hea 04 has been achieved, with further details in Section 7.0. All results are based on the output from dynamic thermal simulation software IES-VE 2022, which is fully compliant with CIBSE Applications Manual AM11.

Criterion 2: The new buildings within the Proposed Development have been analysed to identify opportunities for implementation of passive design measure throughout Section 5.0

Criterion 3: Passive design measures as listed in Table 23 within Section 5.10 have been proposed to be implemented.

Criterion 4: The results in this report have confirmed the performance of the new buildings of the Proposed Development. The reduced total energy demand and carbon dioxide (CO_2-eq) emissions resulting from the passive design measures have been quantified in Section 5.10.

5.12.2 One credit – Free cooling

Criterion 5: Yes, achieves the first credit as detailed in Section 5.12.1.

Criterion 6, 7 & 8: Not undertaken.

5.12.3 One credit – Low and Zero Carbon technologies

Criterion 9: A feasibility study has been carried out for the Proposed Development, as detailed in Section 2.0.

Criterion 10: The most appropriate on-site LZC energy sources for the Proposed Development has been specified in Section 2.4 and 2.5.

Criterion 11: Local LZC technologies for the Proposed Development have been specified in line with the feasibility study recommendations, detailed in Section 2.4 and 2.5.

Criterion 12: The reduced regulated carbon dioxide (CO_2-eq) emissions resulting from the feasibility study has been quantified in Section 2.5.

5.13 Passive Design Analysis Summary

Additionally, as per BREEAM 2018 NC methodology requirements, this passive design analysis takes into account:

- Site location – Section 5.1
- Site weather – Section 5.2
- Microclimate – Section 5.3
- Building layout – Section 5.4
- Building orientation – Section 5.4
- Building form – Section 5.4
- Building fabric – Section 5.5
- Thermal mass or other fabric thermal storage – Section 5.6
- Building occupancy type – Section 5.7
- Daylighting strategy – Section 5.8
- Ventilation strategy – Section 5.9
- Adaptation to climate change – Section 5.11

This analysis was carried out as part of the design stage review during concept design of the new buildings in the Proposed Development. The analysis concludes that based on the modelling scope and results, 2 no. credits for passive design analysis and 1 no. credit for LZC technologies can be awarded to the new buildings of the Proposed Development.

Internal Daylight Analysis

6.0 Internal Daylight Analysis

An internal daylight analysis has been carried out for all occupied spaces of the new teaching block to assess the internal daylight levels and advise on the Proposed Development's performance in achieving the credits associated with BREEAM New Construction 2018 Hea 01, which are:

- Daylighting (two credits)
- View Out (one credit)

Key points of the simulation include:

- Tested on a horizontal plane at 0.7 m above the floor,
- Grid size of 0.25m
- Margin of 0.5 m from the internal walls,
- Using climatic data for the location of the site

Table 22 shows the key properties that have been applied in the model, including reflectance of the internal surfaces and the visual light transmittance of the windows. They are based on standard 'neutral' colours that are likely to be applied on relevant elements. It should be noted that changes to these elements and the corresponding figures will influence the overall results of the assessment.

	Material	Reflectance (%)
Internal walls	Off white plaster	80.0
Internal floor	Grey	60.0
Internal ceiling	White painted	90.0
External walls	Brick Red	40.0
Ground floor	Brown	30%
Glazing	Light transmittance 71%	

Table 24: Reflectance of the internal surfaces

6.1 Daylighting

Assessment for the occupied spaces in the new teaching block has been undertaken in line with BREEAM New Construction 2018 Hea 01 issue requirement to assess internal daylight levels. The requirements for the daylighting criteria and corresponding results are summarised in Table 25 and shown in Figure 22 and 23.

Area Type	Credits	Percentage area compliance	Average daylight illuminance (averaged over entire space)	Minimum daylight illuminance at worst lit point
Target: Schools – occupied spaces	2	>80%	At least 300 lux for 2000 hours per year or more	At least 90 lux for 2000 hours per year or more
Results: Teaching Block occupied spaces	2	>80%	Pass	Pass

Table 25 – Space type and illuminance requirements (Table 5.3 of BREEAM NC 2018)

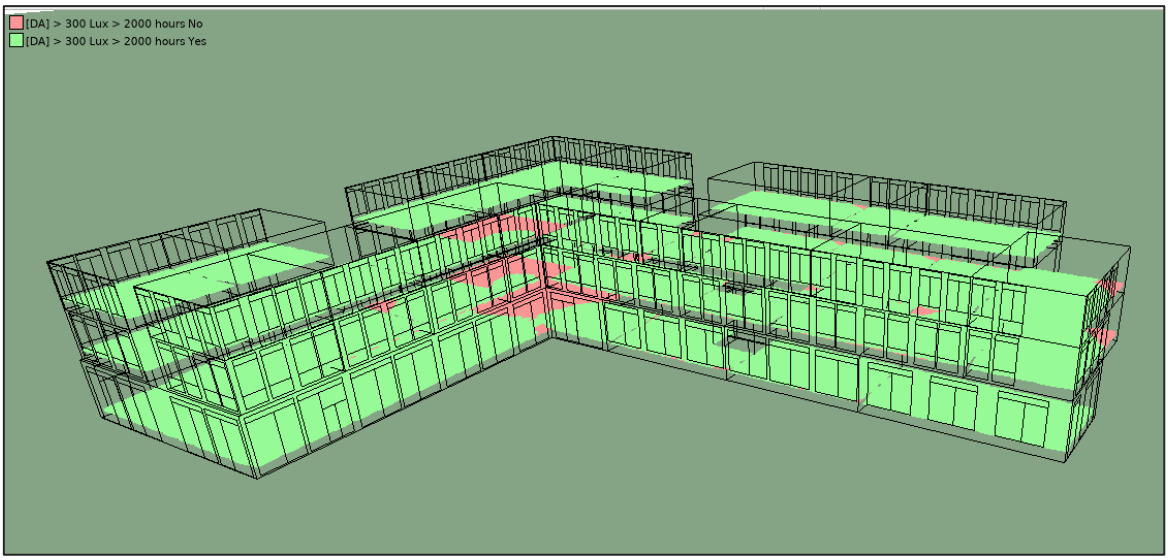


Figure 22 – Summary of occupied spaces in the new teaching block with average daylight illuminance of at least 300 lux for 2000 hours per year or more

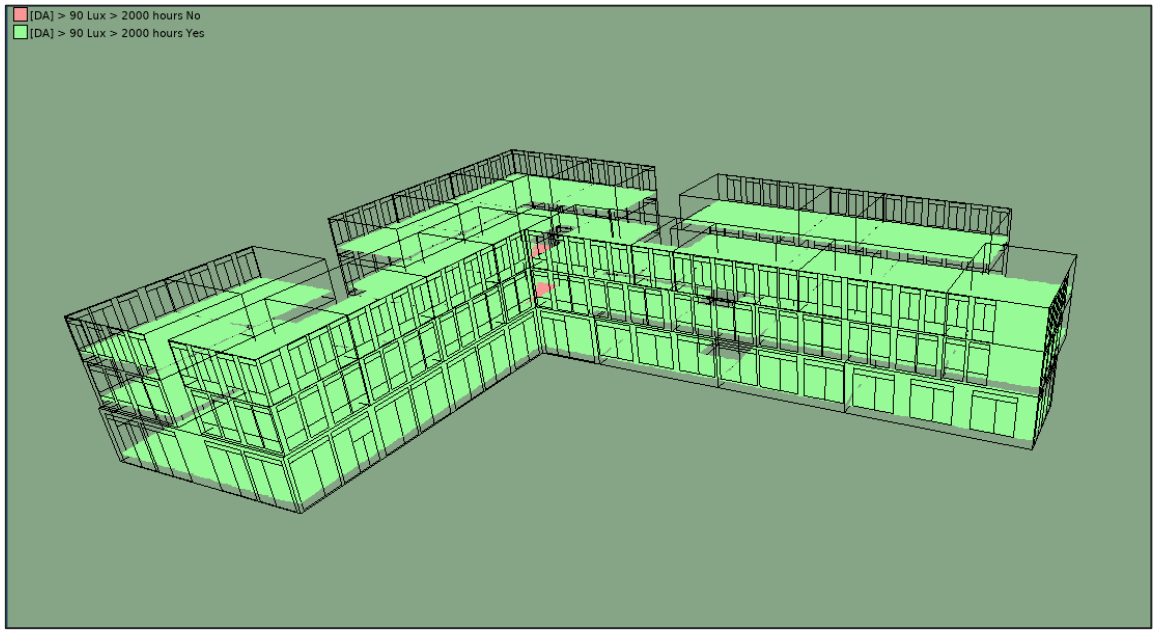


Figure 23 – Summary of occupied spaces in the new teaching block with minimum daylight illuminance of at least 90 lux for 2000 hours per year or more

6.2 View Out

A view out assessment has been also been carried out for the occupied spaces in the new teaching block. Based on the view out requirements set out by BREEAM NC 2018, 95% of the floor area in 95% of spaces for each relevant building area should provide an adequate view out.

Based on the corresponding room depths and percentage window required based on Table 1 of BS82061 (Lighting for Buildings), the assessed spaces within the new teaching block are assessed for the view out criteria. Less than 95% of the floor area in 95% of spaces in the building area provides an adequate view out and therefore the windows provided will not be able to deliver an adequate view out of a landscape, adjacent buildings or an internal courtyard at seated eye level.

Space Name	View Out Criteria						
	Room Depth (d)	Floor area (m^2)	Wall area (m^2)	Window area (m^2)	% Window/Wall area (A)	% Window /Wall Requirement (B)	(A) < (B)
Breakout space	< 8m	88.59	63.91	29.80	46.6%	25.0%	Yes
ICT classroom	< 8m	80.12	38.84	14.90	38.4%	20.0%	Yes
ICT classroom	> 14m	80.70	66.28	17.88	27.0%	35.0%	No
ICT classroom	< 8m	75.43	36.56	14.90	40.8%	20.0%	Yes
ICT classroom	< 8m	68.11	33.29	11.92	35.8%	20.0%	Yes
Dining Hall	< 8m	528.11	283.24	136.31	48.1%	35.0%	Yes
DT1	< 8m	108.47	96.99	27.37	28.2%	20.0%	Yes
Staff room	<8m	12.91	0.00	0.00	0.0%	20.0%	No
DT3	< 8m	81.11	47.95	10.15	21.2%	20.0%	Yes
DT4	< 8m	86.86	51.42	10.15	19.7%	20.0%	No
DT2	< 8m	81.44	48.77	15.23	31.2%	20.0%	Yes
General Classroom	< 8m	56.41	24.74	11.92	48.2%	20.0%	Yes
General classroom	< 8m	55.11	26.71	11.92	44.6%	20.0%	Yes
General classroom	< 8m	56.90	27.23	11.92	43.8%	20.0%	Yes
General classroom	< 8m	56.41	26.99	11.92	44.2%	20.0%	Yes
General classroom	< 8m	55.67	53.73	23.84	44.4%	20.0%	Yes
General classroom	< 8m	53.59	24.72	11.92	48.2%	20.0%	Yes
General Classroom	< 8m	56.18	13.29	5.96	44.9%	20.0%	Yes
General classroom	< 8m	55.09	53.45	23.84	44.6%	20.0%	Yes
General classroom	< 8m	56.99	26.99	11.92	44.2%	20.0%	Yes
General Classroom	< 8m	56.90	25.28	11.92	47.1%	20.0%	Yes
General Classroom	< 8m	55.67	49.25	23.84	48.4%	20.0%	Yes
General Classroom	< 8m	55.09	48.99	23.84	48.7%	20.0%	Yes
General Classroom	< 8m	55.11	24.49	11.92	48.7%	20.0%	Yes
General Classroom	< 8m	56.99	24.74	11.92	48.2%	20.0%	Yes
General classroom	< 8m	56.90	27.58	11.92	43.2%	20.0%	Yes
Kitchen	8-11m	104.86	68.84	15.23	22.1%	25.0%	No
Office	< 8m	6.49	12.16	5.08	41.7%	20.0%	Yes
Pastoral Suite	< 8m	71.04	63.24	15.23	24.1%	20.0%	Yes
Breakout	< 8m	54.78	27.18	11.92	43.9%	20.0%	Yes
Science Classroom	11-14m	80.70	60.76	17.88	29.4%	30.0%	No
Science classroom	< 8m	97.97	47.80	20.86	43.6%	20.0%	Yes
science classroom	< 8m	112.02	54.31	23.84	43.9%	20.0%	Yes
Science Classroom	< 8m	87.22	38.90	17.88	46.0%	20.0%	Yes
Science Classroom	< 8m	87.64	38.95	14.90	38.3%	20.0%	Yes
Science prep room	< 8m	39.62	17.64	8.94	50.7%	20.0%	Yes
Science Classroom	< 8m	84.35	37.49	17.88	47.7%	20.0%	Yes
Science Classroom	< 8m	79.67	35.28	17.88	50.7%	20.0%	Yes
science prep room	< 8m	48.34	27.42	11.92	43.5%	20.0%	Yes
Science Classroom	< 8m	74.43	33.49	14.90	44.5%	20.0%	Yes
Science Office	< 8m	28.10	12.47	5.96	47.8%	20.0%	Yes
Seminar room	< 8m	56.40	24.74	11.92	48.2%	20.0%	Yes
Staff area	< 8m	78.76	69.52	29.80	42.9%	25.0%	Yes
Staff Area	< 8m	55.68	14.25	5.96	41.8%	20.0%	Yes
Compliance	No						

Table 26: BREEAM Hea 01 Assessment Summary for View Out Criteria

6.3 Daylighting Conclusion

The overall result of this study shows that the occupied spaces in the new teaching block meet the daylighting recommendations set out by industry guidance and BREEAM NC 2018. Therefore, it can be anticipated that the building will receive adequate internal daylight levels, which can in turn support the health, wellbeing, and productivity of the building occupant. The view out criteria, however, has not been met. 2 no. credits can therefore be awarded be daylighting, and no credits are awarded for view out.

Thermal Comfort Assessment

7.0 Thermal Comfort Assessment

A thermal comfort assessment has been carried out for all occupied spaces of the new teaching block to assess the risks of overheating and the thermal comfort conditions in the occupied areas in accordance with CIBSE TM52, BB101 (overheating and ventilation criteria), and BREEAM NC 2018 Hea 04 criteria. Key inputs to the model are summarised below:

- Internal gains: The occupancy, equipment and lighting gains for the occupied spaces have been based on BB101 guide and is summarised below:

Room type	Occupancy (m^2/person)	Equipment gain (W/m^2)	Lighting gain (W/m^2)
Classroom	1.5	10	7.2
Office	6.7	8	8
Seminar room	3	5	12
Lab	1.5	10	12

Table 27 – Internal gains for occupied spaces in the new teaching block

- Weather file: London Heathrow DSY1 2020 (current), London Heathrow DSY1 2050 (future)
- Window opening types (All double-glazed with g-value of 0.30):

Opening type	Opening category	Openable area (%)	Max. opening angle (°)
Bottom Hung window	Bottom hung	20	Equivalent to 100mm restrictors
Side Hung window/door	Side hung	20	Equivalent to 100mm restrictors
Glazed Doors	Side Hung	100	90
Louvers	Louvers	65	-
Fixed window	-	0	0

Table 28 – Opening types in the new teaching block

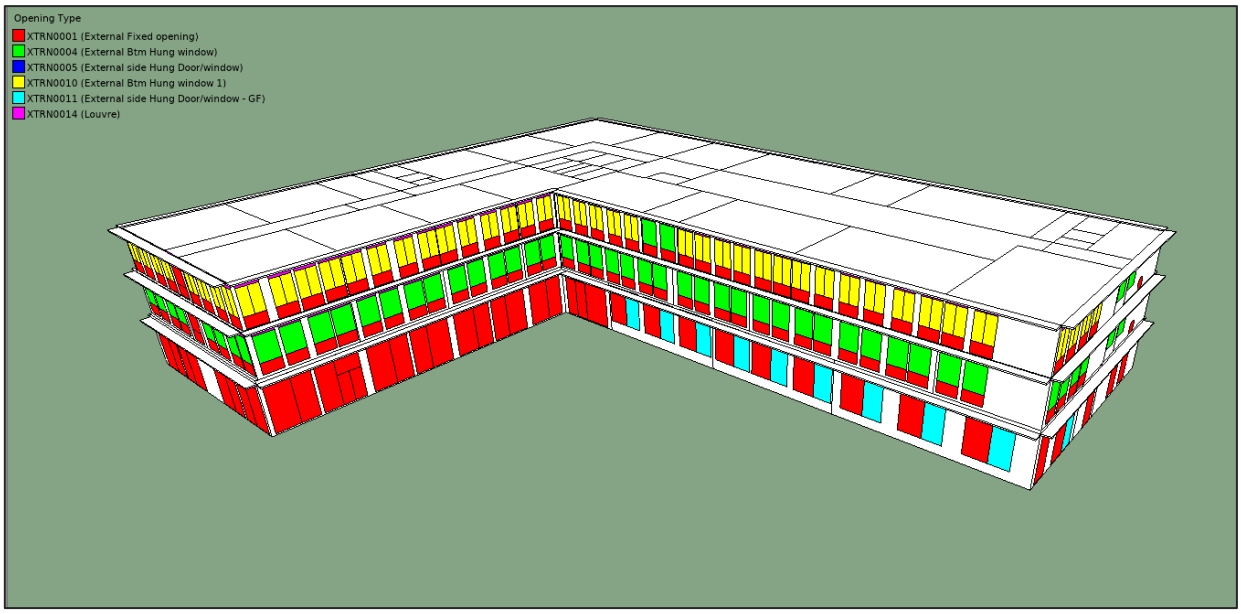


Figure 24 - Opening types in the new teaching block

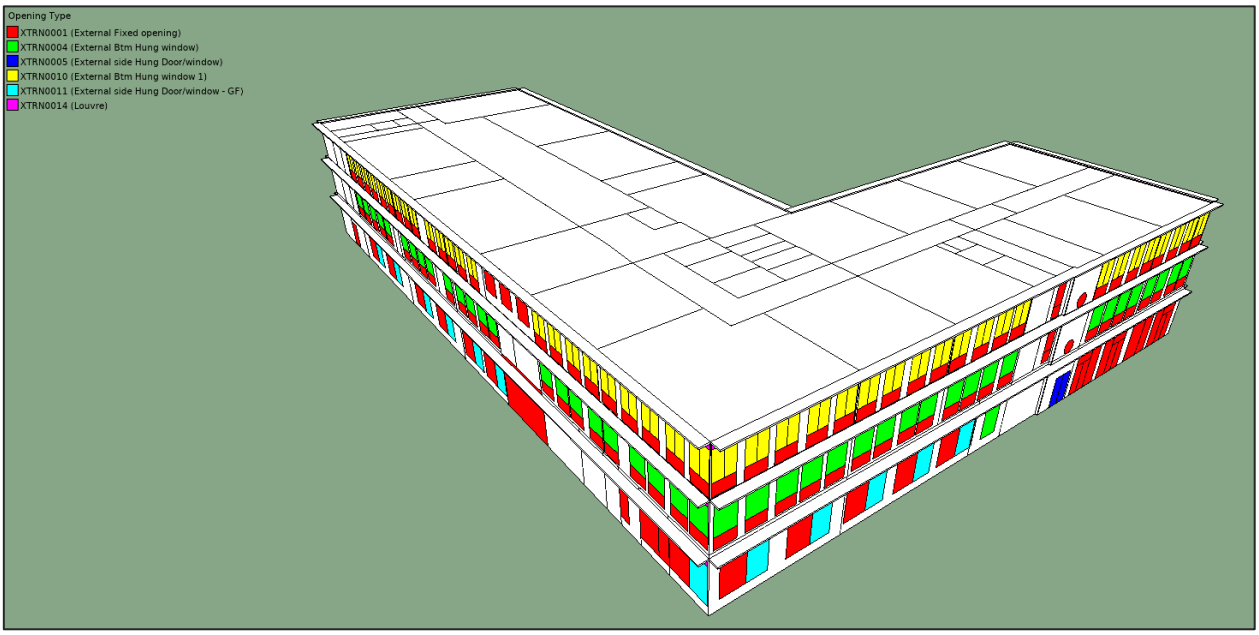


Figure 25 - Opening types in the new teaching block

- Window opening profile: Windows modelled to be open between occupied hours of 09:00-16:00 when:
  - Internal temperatures exceed 19°C **and** internal temperatures are higher than external temperatures **OR**
  - Internal CO_2 concentration levels exceed 950ppm
- Air exchange: MVHR to supply 20l/s/person when internal temperatures exceed 27°C, air supply of 10l/s/person all other times; The infiltration rate is assumed at 0.25 air changes per hour (ach)
- Space heating and cooling: Where applicable, space heating provided with setpoint of 21°C, space cooling provided (to dining hall) with setpoint of 23°C
- Exposed mass: Exposed mass is proposed for the internal ceilings of the new teaching block, leaving the services and structure exposed with open ceiling/plenums and therefore increasing the thermal mass.
- Shading: Overhangs are modelled for the proposed building as shown in Figure 24 and 25.

7.1 Thermal Comfort Results

The overheating risks and thermal comfort conditions of the occupied spaces were assessed for current and future climate scenarios.

7.1.1 Natural/Mixed-mode ventilated areas

Space	Criterion 1: H_e	Criterion 2: W_e	Criterion 3: T_{upp}	Pass / Fail
Breakout space	2.4	8	3	Pass
ICT classroom	2.1	4	2	Pass
ICT classroom	1.5	3	2	Pass
ICT classroom	2.1	4	2	Pass
ICT classroom	2.1	4	2	Pass
Dining Hall	0	0	0	Pass
DT1	2.6	4	2	Pass
Staff room	1.2	3	2	Pass
DT3	3	6	3	Pass
DT4	3.2	6	3	Pass
DT2	2.9	5	2	Pass
General Classroom	2	4	2	Pass
General classroom	2	4	2	Pass
General classroom	1.4	3	2	Pass
General classroom	1.7	3	2	Pass
General classroom	2.3	4	2	Pass
General classroom	2.1	4	2	Pass
General Classroom	1.5	3	2	Pass
General classroom	1.5	3	2	Pass
General classroom	2	4	2	Pass
General Classroom	2.4	5	2	Pass
General Classroom	2.4	4	2	Pass
General Classroom	1.7	3	2	Pass
General Classroom	2.3	4	2	Pass
General Classroom	2.4	5	2	Pass
General classroom	2.1	4	2	Pass

Space	Criterion 1: H_e	Criterion 2: W_e	Criterion 3: T_{upp}	Pass / Fail
Kitchen	0	0	0	Pass
Freezer	0	0	0	Pass
Dry Store	0	0	0	Pass
Cold Store	0	0	0	Pass
Office	0.9	2	1	Pass
Changing	0	0	0	Pass
WC	0	0	0	Pass
Pastoral Suite	0	0	0	Pass
Science Classroom	1.8	3	2	Pass
Science classroom	2.3	4	2	Pass
science classroom	2.9	5	2	Pass
Science Classroom	2.9	5	2	Pass
Science Classroom	2.7	5	2	Pass
Science prep room	3.6	5	2	Pass
Science Classroom	3.2	5	2	Pass
Science Classroom	3.2	5	2	Pass
science prep room	2.7	5	2	Pass
Science Classroom	2.7	5	2	Pass
Science Office	3	5	2	Pass
Seminar room	0.8	3	2	Pass
Servery	0	0	0	Pass
Dishwash	0	0	0	Pass
Staff area	2.2	7	2	Pass
Staff Area	0.4	3	1	Pass

Table 29 – Thermal Comfort results for current weather file

Space	Criterion 1: H_e	Criterion 2: W_e	Criterion 3: T_{upp}	Pass / Fail
ICT classroom	4.1	6	3	Pass
Dining Hall	0	0	0	Pass
Staff room	3.9	6	3	Pass
General classroom	4.4	6	3	Pass
Kitchen	0.9	2	1	Pass
Freezer	0	0	0	Pass
Dry Store	0.6	2	1	Pass
Cold Store	0.6	2	1	Pass
Office	3.9	6	3	Pass
Changing	0.6	2	1	Pass
WC	0.3	1	1	Pass
Pastoral Suite	0	0	0	Pass
Servery	1.2	2	1	Pass
Dishwash	0.3	1	1	Pass
Staff Area	1.9	10	2	Pass
Breakout space	5.6	14	4	Fail
ICT classroom	5.2	8	3	Fail
ICT classroom	5.6	8	3	Fail
ICT classroom	5.5	8	3	Fail
DT1	5.8	8	3	Fail
DT3	6.5	9	4	Fail
DT4	6.5	10	4	Fail
DT2	5.9	9	3	Fail
General Classroom	5.2	8	3	Fail
General classroom	5	8	3	Fail
General classroom	4.2	7	3	Fail
General classroom	4.2	7	3	Fail
General classroom	5	8	3	Fail
General classroom	5.2	8	3	Fail
General Classroom	4.7	7	3	Fail
General classroom	5	8	3	Fail
General Classroom	5.6	8	3	Fail
General Classroom	5.3	8	3	Fail
General Classroom	4.5	8	3	Fail

General Classroom	5.5	8	3	Fail
General Classroom	5.5	8	3	Fail
General classroom	5.5	8	3	Fail
Science Classroom	4.8	8	3	Fail
Science classroom	5.3	9	3	Fail
science classroom	5.9	9	3	Fail
Science Classroom	5.9	9	4	Fail
Science Classroom	5.9	9	4	Fail
Science prep room	6.5	10	4	Fail
Science Classroom	6.1	9	4	Fail
Science Classroom	6.4	9	4	Fail
science prep room	5.9	9	3	Fail
Science Classroom	5.9	9	3	Fail
Science Office	6.1	9	4	Fail
Seminar room	3.5	8	3	Fail
Staff area	5.1	14	4	Fail

Table 30 – Thermal Comfort results for future weather file

7.1.2 Air-Conditioned spaces

Active cooling is provided to the dining hall, where there are no openable windows provided. In order to provide a prediction of building user perception relating to how comfortable the building interior will be during the summer and winter period, two indexes have been calculated the Percentage People Dissatisfied (PPD) and Predicted Mean Vote (PMV), with comfort cooling applied in summer and heating in winter. Assumed building occupied hours are 9:00 to 16:00, 5 days a week.

Space	Criteria	Description	Current weather file	Future weather file
Dining Hall	Operative Temperature (°C)	Winter 20˚C ± 2˚C (no less than 18˚C) and Summer 22˚C ± 2˚C (no more than 25˚C)	Pass	Pass
	Predicted Mean Vote (PMV)	PMV within acceptable criteria (<-0.5 - >0.5) should not exceed 0.5 for more than 3% of occupied hours (62,4 occupied hours)	Pass	Pass
	Percentage People Dissatisfied (PPD) (%)	PPD within acceptable criteria (<10%) should not exceed 10% for more than 3% of occupied hours (62,4 occupied hours)	Pass	Pass

Table 31 – Thermal Comfort Criteria for air-conditioned spaces

7.2 Ventilation Results

The following figure shows the results from the analysis and indicates that the carbon concentration in all the occupied teaching spaces never exceeds 1000 ppm. Hence the occupants have the capability to maintain a suitable air quality throughout the occupied time.

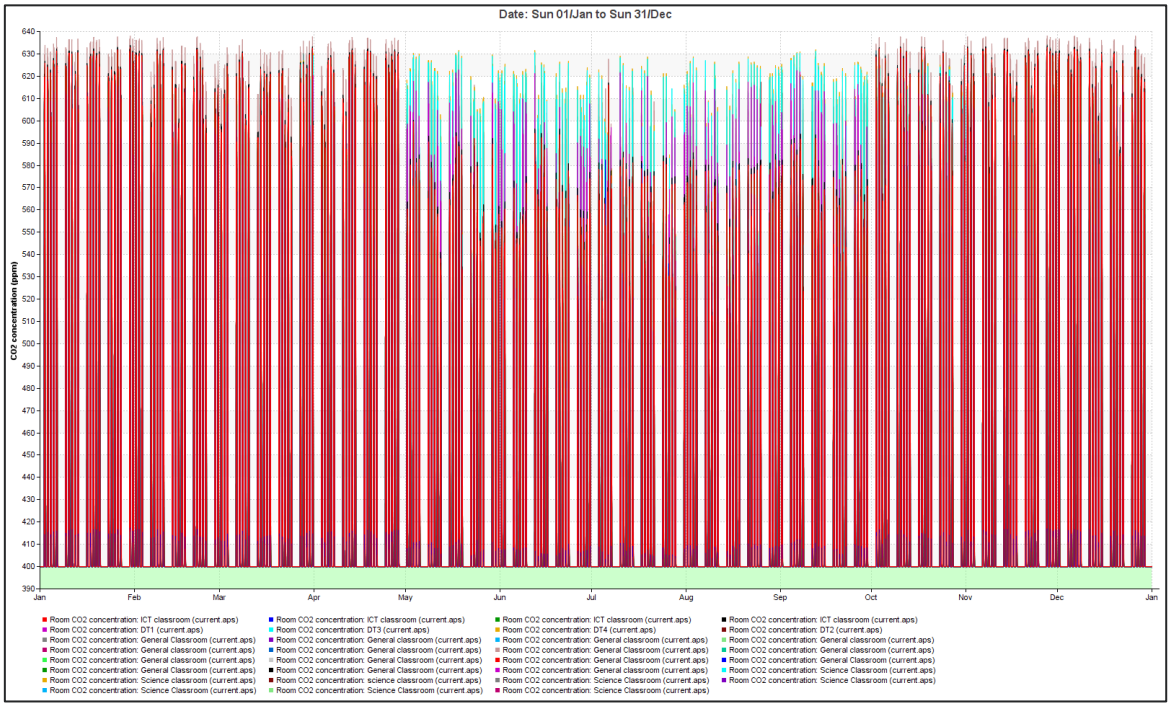


Figure 26 - All classrooms in the model, hourly CO_2 concentration for the whole year (current weather file)

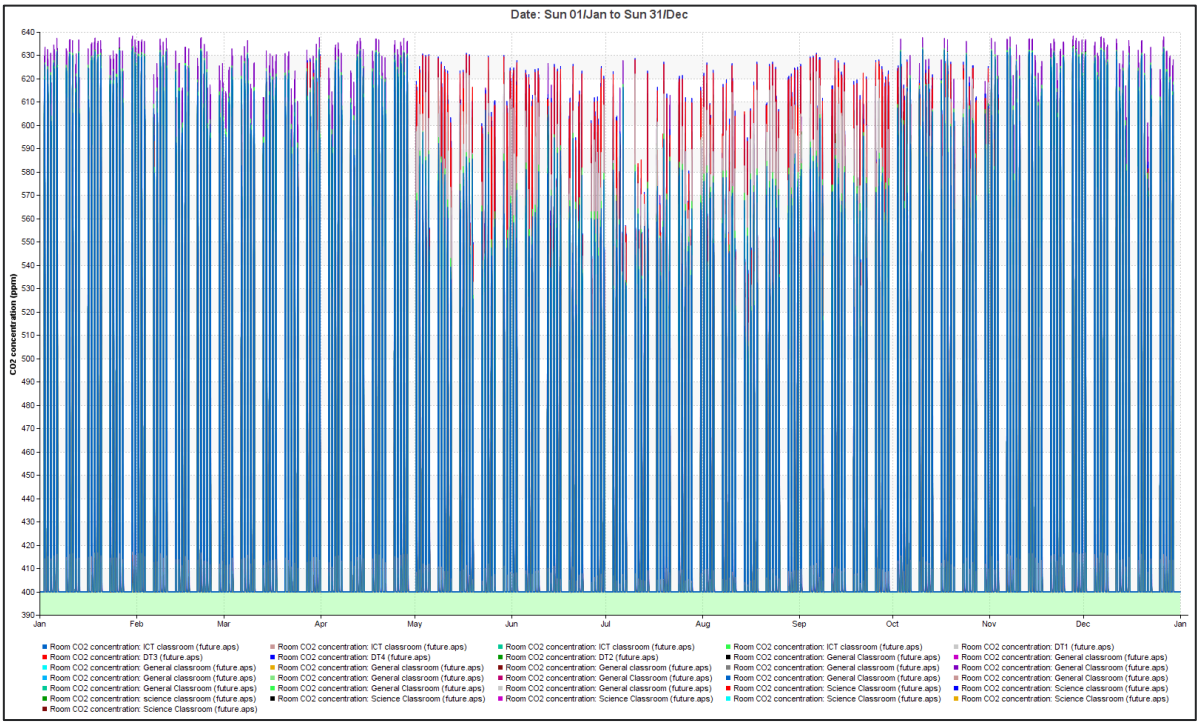


Figure 27 - All classrooms in the model, hourly CO_2 concentration for the whole year (future weather file)

7.3 Thermal Comfort Conclusion

Space	Current weather file (DSY 1 2020s)		Future weather file (DSY1 2050s)	
	Thermal comfort	CO_2 levels	Thermal Comfort	CO_2 levels
Teaching Block – Occupied spaces	Pass	Pass	Fail	Pass

Table 32 – Summary table of results from thermal comfort assessment of new teaching block

The key results are summarised below:

Thermal Comfort

The results of the dynamic thermal simulations undertaken for the Proposed Development indicate that, under current DSY1 2020, all rooms could have comfortable internal conditions for both summer and winter period. Assessment with future DSY1 2050 weather file suggests that summertime overheating may arise in the future, and mitigation measures may be needed to ensure overheating risk is kept to a minimum. A range of passive design measures have been incorporated where feasible, to optimise thermal comfort conditions through a combination of exposed ceilings, reduced glazing g-value, optimised building orientation, external shading, openable windows and efficient lighting. Openable windows have currently been modelled with restrictors, but it is believed these restrictors can be overridden to provide purge ventilation if needed. Purge ventilation can also be run through the proposed MVHR units to reduce overheating risks.

Ventilation and air quality

The results of the dynamic thermal simulations undertaken for the Proposed Development indicate that, the carbon concentration in all the occupied teaching spaces never exceeds 1000ppm. Hence the occupants have the capability to maintain a suitable air quality throughout the occupied time.

BREEAM NC 2018 Hea 04

First Credit - Justification

Criterion 1 and 2

All results are based on the output from dynamic thermal simulation software IES-VE 2022, which is fully compliant with CIBSE Applications Manual AM11.

Criterion 3

The results in this report have confirmed that the performance of both naturally ventilated/mixed-mode and air-conditioned spaces within the building are compliant with relevant criteria for summer and winter periods.

Criterion 4:

The PMV and PPD of the air-conditioned spaces have been provided to the BREEAM assessor.

7.4 Second credit - Justification

Criterion 5

Criteria 1 to 4 have been achieved.

Criterion 6

The results in this report show that thermal comfort criteria have been met for air-conditioned spaces within the building under the specified projected climate change scenario.

Criterion 7

A range of passive design measures have been incorporated where feasible, to optimise thermal comfort conditions through a combination of exposed ceilings, reduced glazing g-value, optimised building orientation, external shading, openable windows and efficient lighting. Openable windows have currently been modelled with restrictors, but it is believed these restrictors can be overridden to provide purge ventilation if needed. Purge ventilation can also be run through the proposed MVHR units to reduce overheating risks.

Criterion 8

The PMV and PPD of the air-conditioned spaces have been provided to the BREEAM assessor.

7.5 Third credit - Justification

Criterion 9

Criteria 1 to 4 have been achieved.

Criterion 10

The thermal modelling analysis was conducted in close contact with the design team. All temperature control strategies applied in the thermal model are in line with the proposed specifications. It is also anticipated that the end user will be informed at handover. Hence it is believed that this criterion has been met.

Criterion 11

Further information from MEP designers will be needed as this is beyond the scope of thermal modelling. Should this be provided the third Hea04 credit will be achieved.

Appendices

Appendix A – Site Plan

Appendix B – SBEM Summary Sheet

Building Regulations 2021 Volume 2	Kneller Hall								
Building Type	**Address**		**As-Designed/ As-Built Drawings**	**SBEM Level**	**Asset Rating (A-G) (0-150)**	**BER**	**TER**	**Baseline**	**BER/TER Improvement (%)**	**BER/Baseline Improvement (%)**
D1: Primary or Secondary School (Secondary) D2: General Assemby and Leisure (Sports Centre)	Kneller Hall. Twickenham, London TW2 7DU		As-Designed	5						

Construction Element	**U-Value**	**Description**
New External Wall	0.15	102.5mm brickwork, 200mm Rockwool DuoSlab (0.035), 50mm cavity, breather membrane, 12mm Euroform Cement Particle Board, 100mm acoustic quilt (0.032) between metal stud, VCL, 2 x 15mm gyproc duraline (TBC)
Existing External Wall	2.4	Existing wall
New Ground Floor	0.12	65mm screed, separation layer, 120mm Kingspan K103 insulation (0.018), 150mm concrete slab (TBC)
Existing Ground Floor	1.2	Existing concrete ground floor slab
New Flat Roof	0.12	Flat roof construction with 180mm PIR insulation (0.02 conductivity)
New Pitched Roof (Joists)	0.12	220mm mineral wool over joists, 150mm joists fully filled with mineral wool (0.042), 12.5mm plasterboard (TBC)
Existing Roof	2.3	Existing Roof structure

Construction Element	**U-Value**	**G Value**	**Frame Factor**	**Description (manufacturer, make and model)**
New External Window/Glazed Door	1.20	0.63	10%	Double glazing, whole window U-value of 1.4, g-value of 0.63
Existing window/glazed door	4.80	0.58	10%	Single glazing, whole window U-value of 4.8, g-value of 0.63
New Solid Doors	1.20	n/a	n/a	Whole element U-value
Existing Solid Doors	1.60	n/a	n/a	Whole element U-value
Spandrel Panels	0.2	n/a	n/a	Whole element U-value
Ventilation Louvres	3.0	n/a	n/a	Whole element U-value

Construction Notes	**U-Value**	**G Value**	**Frame Factor**	**Description (manufacturer, make and model)**
Construction Details				
Air-permeability	3 m3/h.m2 - New Buildings			25 m3/h.m2 - Existing Buildings

Heating and Cooling	**System Details**	**Emitter**	**Controls**
Heating System	3 no. centralised ASHP-serving oversized radiators (SCOP 3.95)	Radiators/UF heating	Time, Temperature and optimum start/stop Controls
Heating System 2	Local WSHP (water-to-water) system (SCOP 3.66)	Radiators/UF heating	Time, Temperature and optimum start/stop Controls
Heating/Cooling System 2	FCU (SCOP 3.66, SEER 5.5, EER 4.6)	Wall/Ceiling Cassette	Time, Temperature and optimum start/stop Controls
Heating/Cooling System 3	GSHP (water-to-air) (SCOP 3.28)	Radiators	Time, Temperature and optimum start/stop Controls
CHP	N		

Hot Water	**System Details**	**Secondary Circulation**	**Circulation Losses (W/m)**	**Pump Power (kW)**	**Loop Length (m)**		**Storage Losses (kWh/l.day)**	
Hot Water System 1	Kneller Hall Main Building: Centeralised ASHP-serving HWS	N	n/a	n/a	n/a		0.0063	
Hot Water System 2	Teaching Building: Electric water heater with 300L central storage for WCs, 600L central storage for kitchen	N	n/a	n/a	n/a		0.0063	
Hot Water System 3	Sports Pavilion :Electric water heater with 960L central storage	N	n/a	n/a	n/a		0.0063	
Hot Water System 4	Guard House: Electric water heater with 100L cylinder	N	n/a	n/a	n/a		0.0063	
Hot Water System 5	School Hall: Electric water heater with 300L cylinder	N	n/a	n/a	n/a		0.0063	
Hot Water System 5	Sports Centre: Electric water heater with 1890L cylinder	N	n/a	n/a	n/a		0.0063	

Ventilation	**System Details**	**SFP (W/l/s)**	**Leakage tested ductwork CEN Classification**	**AHU CEN leakage standards class**	**Heat Recovery**		**Heat Recovery Type**	**Variable HR**
Mechanical Ventilation (extract)	Standard extract to WCs, Shower, Kitchen	0.30	n/a	n/a	N		n/a	N
Mechanical Ventilation (supply-extract)	Teaching Block: MVHR to classrooms	2.20	n/a	n/a	Y		Plate Heat Exchanger	N
Mechanical Ventilation (supply-extract)	Teaching Block: Centralised AHU with heat recovery to dining hall and kitchen	2.20	n/a	n/a	Y		Plate Heat Exchanger	N
Mechanical Ventilation (supply-extract)	Sporst Pavilion: MVHR to changing area	2.20	n/a	n/a	Y		Plate Heat Exchanger	N
Mechanical Ventilation (supply-extract)	Guard House: MVHR to music rooms	2.20	n/a	n/a	Y		Plate Heat Exchanger	N
Mechanical Ventilation (supply-extract)	School Hall: Central AHU to auditorium	2.20	n/a	n/a	Y		Plate Heat Exchanger	N
Mechanical Ventilation (supply-extract)	Sports Centre: AHU with HR to sports hall and pool hall, MVHR to all other spaces	2.20	n/a	n/a	Y		Plate Heat Exchanger	N

Electrical Flow Control	**Description**
Power Correction Factor	Y	<0.9
Separate Metering	Y	Lighting, Heating, Air conditioning, Ventilation all on separate meters, BMS system warns for 'out of range' values

Renewables	**Description**
PV	Monocrystalline silicone solar PV (with 21.7% module efficiency), South-facing with 30 degree pitch, total of 217.31kWp: Teaching Block - 672.3m2 (approximately equal to 146.16 kWp) Sports Hall - 421.1 m2 (approximately equal to 91.56 kWp) Sports Pavilion: 154.6 m2 (approximately equal to 33.6kWp)
Solar Water Heating	N
Wind Turbine	N

Lighting	**Description**	
Lighting	All lights with average light efficacy of 125Lm/W and LOR=1	
Lighting Controls	PIR auto-on-off sensors to WC and Circulation, Manual on-auto-off in all other main occupied spaces	Parasitic power of 0.1W/m2

Sign Off of details	**Name**	Yin Mui Tang	**Date**	17.08.2022	By signing this document, I declare that the aforementioned details are all correct as per the final "as build" specifications:	**Name**		**Date**	
						Sign			

Appendix C – GLA spreadsheet, Space Heating Demand and EUI (New Developments)

Non-residential predicted energy use

Building type	GIA	EUI & space heating demand (kWh/year)									Has the following energy use been included?		Results		Table 4 of the guidance comparison		Methodology used		
		Space heating demand	Annual Electricity Use	Annual Gas Use	Annual Oil Use	Annual Biomass Use	Annual District Htg Use	Annual District Clg Use	Elec Generation, Gross	Solar Thermal Generation	Regulated	Unregulated	EUI (kWh/m²/year) (excluding renewable energy)	Space heating demand (kWh/m²/year) (excluding renewable energy)	EUI value from Table 4 of the guidance (kWh/m²/year) (excluding renewable energy)	Space heating demand from Table 4 of the guidance (kWh/m²/year) (excluding renewable energy)	Software	Operational energy use assessment	notes (if expected performance differs from the Table 4 values in the guidance or other software used)
					if applicable	if applicable	if applicable	if applicable	if applicable	if applicable									
School	*8802.29*	212268.9838	264262.3504	0					22.6918		Yes	Yes	30.02457794	24.1152	65	15	Part L2 - approved DSM	Other (provide details in column T)	Part L2 - Aproved DSM (IESVE)

Non-residential

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-residential buildings

	Carbon Dioxide Emissions for non-residential buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2021 of the Building Regulations Compliant Development	39.2	
After energy demand reduction (be lean)	37.7	
After heat network connection (be clean)	37.7	
After renewable energy (be green)	8.8	

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-residential buildings

	Regulated non-residential carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be lean: savings from energy demand reduction	1.6	4%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	28.9	74%
Total Cumulative Savings	**30.5**	**78%**
Annual savings from off-set payment	8.8	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**263**	-
Cash in-lieu contribution (£)	**25,009**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development

Appendix D – GLA spreadsheet, Space Heating Demand and EUI (Existing Buildings)

Building type	GIA	EUI & space heating demand (kWh/year)									Has the following energy use been included?		Results		Table 4 of the guidance comparison		Methodology used		
		Space heating demand	Annual Electricity Use	Annual Gas Use	Annual Oil Use	Annual Biomass Use	Annual District Htg Use	Annual District Clg Use	Elec Generation, Gross	Solar Thermal Generation	Regulated	Unregulated	EUI (kWh/m^2/year) (excluding renewable energy)	Space heating demand (kWh/m^2/year) (excluding renewable energy)	EUI value from Table 4 of the guidance (kWh/m^2/year) (excluding renewable energy)	Space heating demand from Table 4 of the guidance (kWh/m^2/year) (excluding renewable energy)	Software	Operational energy use assessment	notes (if expected performance differs from the Table 4 values in the guidance or other software used)
					if applicable	if applicable	if applicable	if applicable	if applicable	if applicable									
School	*4387.05*	1372461.859	1002723.428	0							Yes	Yes	228.5643948	312.8439063	65	15	Part L2 - approved DSM	Other (provide details in column T)	Part L2 - Aproved DSM (IESVE)

Non-residential

Table 3: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for non-residential buildings

	Carbon Dioxide Emissions for non-residential buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2021 of the Building Regulations Compliant Development	41.0	
After energy demand reduction (be lean)	38.5	
After heat network connection (be clean)	38.5	
After renewable energy (be green)	33.8	

Table 4: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for non-residential buildings

	Regulated non-residential carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be lean: savings from energy demand reduction	2.5	6%
Be clean: savings from heat network	0.0	0%
Be green: savings from renewable energy	4.7	12%
Total Cumulative Savings	**7.2**	**18%**
Annual savings from off-set payment	33.8	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**1,014**	-
Cash in-lieu contribution (£)	**96,373**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless Local Planning Authority price is inputted in the 'Development

Appendix E LBRuT Sustainable Construction Checklist

LBRUT Sustainable Construction Checklist - June 2020

This document forms part of the Sustainable Construction Checklist SPD. This document **must** be filled out as part of the planning application for the following developments: all residential development providing **one or more new residential units (including conversions leading to one or more new units)**, and all other forms of development providing **100sqm or more of non-residential floor space**. Developments including new non-residential development of less than 100sqm floor space, extensions less than 100sqm, and other conversions are strongly encouraged to comply with this checklist. Where further information is requested, please either fill in the relevant section, or refer to the document where this information may be found in detail, e.g. Flood Risk Assessment or similar. **Further guidance** on completing the Checklist may be found in the Justification and Guidance section of this SPD.

Property Name (if relevant):	Kneller Hall, Twickenham	Application No. (if known):	
Address (include. postcode)	Kneller Hall, Twickenham, TW2 7DU		
Completed by:	Yin Mui Tang, Senior Consultant, SRE Ltd, 1 Farnham Rd, Guildford GU2 4RG		
For Non-Residential		*For Residential*	
Size of development (m2)	8812.85	Number of dwellings	

1 MINIMUM COMPLIANCE (RESIDENTIAL AND NON-RESIDENTIAL)

Energy Assessment

	Has an energy assessment been submitted that demonstrates the expected energy and carbon dioxide emissions saving from energy efficiency and renewable energy measures, including the feasibility of CHP/CCHP and community heating systems? If yes, please select TRUE.	TRUE	

Carbon Dioxide emissions reduction

	What is the on site carbon dioxide emissions reduction against a Building Regulations Part L (2013) baseline	77.56	%	
	Policy LP 22 B. and Draft London Plan Policy 9.2.5 require a 35% onsite reduction in CO_2 emissions beyond Building Regulations 2013.			Note: These figures have been provided in accordance to Building Regulations 2021 to reflect current Building Regulations requirements
	What is the percentage reduction from efficiency measures alone	3.83	%	
	Policy LP 22 C. and Draft London Plan Policy 9.2.6 require a 10% onsite reduction in CO2 emissions beyond Building Regulations 2013 from efficiency measures for residential and 15% for non-residential.			
	Percentage of **total** site CO2 emissions saved through renewable energy installation?	68.3	%	
	What is the total remaining carbon to be offset	8.8	Tonne	
	Policy LP 22 B. and Draft London Plan Policy 9.2.4 require Major developments to achieve Zero Carbon after offsetting.			
	Are remaining emissions going to be offset through offset fund payment in accordance with current guidelines issued for the cost per tonne of CO2?	TRUE		
	What is the total predicted cost of offset?	25,080	£	
	The London Plan sets this as £95/tonne per year over 30 years, this should be updated based on As Build calculations.			

1A	MINIMUM POLICY COMPLIANCE (NON-RESIDENTIAL AND DOMESTIC REFURBISHMENT)				
		Please check the Guidance Section of this SPD for the policy requirements			
Environmental Rating of development:					
Non-Residential new-build (100sqm or more)					
	BREEAM Level	**Excellent**	Have you attached a pre-assessment to support this?		**TRUE**
Excellent required under Policy LP22 A 3					
Extensions and conversions for residential dwellings					
	BREEAM Domestic Refurbishment	**Please Select**	Have you attached a pre-assessment to support this?		**Please Select:**
Excellent required under Policy LP22 A 4					
Extensions and conversions for non-residential buildings					
	BREEAM Level	**Excellent**	Have you attached a pre-assessment to support this?		**TRUE**
Excellent required under Policy LP 22					
	Score awarded for Environmental Rating:			**Subtotal**	16
	BREEAM:	Good = *0*, Very Good = 4, Excellent = *8,* Outstanding = *16*			

1B	MINIMUM POLICY COMPLIANCE (RESIDENTIAL)			
			Score	
Water Usage				
	Internal water usage after gray/rainwater systems limited to 105 litres person per day. (Excluding an allowance 5 litres per person per day for external water consumption). Calculations using the water efficiency calculator for new dwellings have been submitted.		*1*	**Please Select:**
	110l/p/d Required for new dwellings under Policy LP22 A 2 105l/p/d required under Draft London Plan Policy SI5			
			Subtotal	**0**

2. ENERGY USE AND POLLUTION						
2.1 Need for Cooling				***Score***		
a.	How does the development incorporate cooling measures? Tick all that apply:					
		Energy efficient design incorporating specific heat demand to less than or equal to 15 kWh/sqm		*6*		**Please Select:**
			Reduce heat entering a building through providing/improving insulation and living roofs and walls	*2*		**TRUE**
			Reduce heat entering a building through shading	*3*		**TRUE**
			Exposed thermal mass and high ceilings	*4*		**TRUE**
			Passive ventilation	*3*		**TRUE**
		Mechanical ventilation with heat recovery		*1*		**TRUE**
		Active cooling systems, i.e. Air Conditioning Unit		*0*		**TRUE**
	See Draft London Plan SI4					
2.2 Heat Generation						
b.	How have the heating and cooling systems, with preference to the heating system hierarchy, been selected (defined in London Plan policy **SI3)** Tick all heating and cooling systems that will be used in the development:			***Score***		
			Connection to existing heating or cooling networks powered by renewable energy	*6*		**FALSE**
			Connection to existing heating or cooling networks powered by gas or electricity	*5*		**FALSE**
			Site wide CHP network powered by renewable energy	*4*		**FALSE**
			Site wide CHP network powered by gas	*3*		**FALSE**
			Communal heating and cooling powered by renewable energy	*2*		**FALSE**
			Communal heating and cooling powered by gas or electricity	*1*		**TRUE**
			Individual heating and cooling	*0*		**FALSE**
	See Draft London Plan SI3					
2.3 Pollution: Air, Noise and Light						
a.	Does the development plan to implement reduction strategies for dust emissions from construction sites?			*2*		**FALSE**
b.	Does the development plan to include a biomass boiler?					**FALSE**
		If yes, please refer to the biomass guidelines for the Borough of Richmond, please see guidance for supplementary information. If the proposed boiler is of a qualifying size, you may need to complete the information request form found on the Richmond website.				
c.	Has an air quality impact assessment been provided					**FALSE**
		If yes, has 'Emissions Neutral' been achieved		*1*		**Please Select:**
		If yes, have occupants of new development been protected from existing pollution		*1*		**Please Select:**
			If no to any of the above are there any sensitive receptors as defined in Policy LP 10 present?	*-1*		**Please Select:**
	see Policy LP 10					
d.	Please tick only one option below					
		Has the development taken measures to reduce existing noise and enhance the existing soundscape of the site?		*3*		**FALSE**
		Has the development taken care to not create any new noise generation/transmission issues in its intended operation?		*1*		**TRUE**
	see Policy LP 10					
e.	Has the development taken measures to reduce light pollution impacts on character, residential amenity and biodiversity?			*3*		**TRUE**
	see Policy LP 10					
f.	Have you attached a Lighting Pollution Report?			*-*		
				Subtotal	**18**	
Please give any additional relevant comments to the Energy Use and Pollution Section below						
Exposed thermal mass in new teaching block						

3. TRANSPORT					
3.1 Provision for the safe efficient and sustainable movement of people and goods					
a.	Does your development provide opportunities for occupants to use innovative travel technologies?				FALSE
Please explain:					
			Score		
b.	Does your development provide for 100% active provision for electric vehicle charging point(s) and have you successfully demonstrated that it would be able to operate satisfactorily in the future expectation of all vehicles being electrically powered?		*2*		TRUE
c.	**For major developments ONLY**: Has a Transport Assessment been produced for your development based on TfL's Best Practice Guidance?				
		If you have provided a Transport Assessment as part of your planning application, please tick here and move to Section 3 of this Checklist.	*5*		TRUE
	See policy LP44				
d.	**For smaller developments ONLY**: Have you provided a Transport Statement?		*5*		Please Select:
e.	Does your development provide cycle storage? (Standard space requirements are set out in the Council's Parking Standards - Local Plan Appendix 3)		*2*		TRUE
		If so, for how many bicycles?	**182**		
		Is this shown on the site plans?			TRUE
	See Local Plan Appendix 3				
f.	Will the development create or improve links with local and wider transport networks? If yes, please provide details.		*2*		FALSE
			Subtotal	**9**	
Please give any additional relevant comments to the Transport Section below					

4	**BIODIVERSITY**								
4.1 Minimising the threat to biodiversity from new buildings, lighting, hard surfacing and people									
a.	Does your development involve the loss of an ecological feature or habitat, including a loss of garden or other green space? (Indicate if yes)					-2			TRUE
		If so, please state how much in sqm?				5941	sqm		
b.	Does your development involve the removal of any tree(s)? (Indicate if yes)								TRUE
		If so, has a tree report been provided in support of your application? (Indicate if yes)							TRUE
c.	Does your development plan to add (and not remove) any tree(s) on site? (Indicate if yes)								FALSE
d.	Please indicate which features and/or habitats that your development will incorporate to improve on site biodiversity:								
		Pond, reedbed or extensive native planting	*6*	Area provided:			sqm		FALSE
		An extensive green roof	*5*	Area provided:		3204	sqm		TRUE
		An intensive green roof	*4*	Area provided:			sqm		FALSE
		Garden space	*4*	Area provided:		2290	sqm		TRUE
		Additional native and/or wildlife friendly planting to peripheral areas	*3*	Area provided:		19205	sqm		TRUE
		Additional planting to peripheral areas	*2*	Area provided:		1578	sqm		TRUE
		A living wall	*2*	Area provided:		25	sqm		TRUE
		Bat boxes	*0.5*						TRUE
		Bird boxes	*0.5*						TRUE
		Swift boxes	*0.5*						FALSE
		Other	*0.5*						TRUE
e.	Does your development use at least 70% of available roof plate as green/brown roof					1			TRUE
	Policy LP 17 requires 70%								
						Subtotal	**15.5**		
Please give any additional relevant comments to the Biodiversity Section below									
The loss of green space is associated with a grassed sports pitch that will become an astro turf all weather sports pitch									

5	**FLOODING AND DRAINAGE**																
5.1	**Mitigating the risks of flooding and other impacts of climate change in the borough**																
	a.	Is your site located in a high flood risk zone (Zone 3)? (Indicate if yes)												*-2*			**FALSE**
			Have you submitted a Flood Risk Assessment? (Indicate if yes)														**FALSE**
	b.	Which of the following measures of the drainage hierarchy are incorporated onto your site? (tick all that apply)															
			Store rainwater for later use											*5*			**FALSE**
			Use of infiltration techniques such as porous surfacing materials to allow drainage on-site											*3*			**TRUE**
			Attenuate rainwater in ponds or open water features											*4*			**FALSE**
			Store rainwater in tanks for gradual release to a watercourse											*3*			**FALSE**
			Discharge rainwater directly to watercourse											*2*			**FALSE**
			Discharge rainwater to surface water drain											*1*			**FALSE**
			Discharge rainwater to combined sewer											*0*			**FALSE**
			Have you submitted a Drainage Statement (Indicate if yes)														**FALSE**
		See Policy LP 21 and Draft London Plan SL 13															
	c.	Please give the change in area of permeable surfacing which will result from your development proposal:											7706.78		sqm		
		Please provide details of the permeable surfacing below									*please represent a loss in permeable area as a negative number*						
														Subtotal	**3**		
	Please give any additional relevant comments to the Flooding and Drainage Section below																

6	**IMPROVING RESOURCE EFFICIENCY**				
6.1 Reduce waste generated and amount disposed of by landfill though increasing level of re-use and recycling					
a.	Will demolition be required on your site prior to construction? *[Points will only be awarded if 10% or greater of demolition waste is reused/recycled]*		*1*		**TRUE**
		If so, what percentage of demolition waste will be reused in the new development?		%	
		What percentage of demolition waste will be recycled?		%	
b.	Does your site have any contaminated land?		*1*		**TRUE**
		Have you submitted an assessment of the site contamination?	*2*		**FALSE**
		Are plans in place to remediate the contamination?	*2*		**FALSE**
		Have you submitted a remediation plan?	*1*		**FALSE**
		Are plans in place to include composting on site?	*1*		**FALSE**
c.	Will a waste management plan and facilities be in place in line with Policy LP24		Yes		
6.2 Reducing levels of water waste					
a.	Will the following measures of water conservation be incorporated into the development? (Please tick all that apply):				
		Fitting of water efficient taps, shower heads etc	*1*		**TRUE**
		Use of water efficient A or B rated appliances	*1*		**TRUE**
		Rainwater harvesting for internal use	*4*		**TRUE**
		Greywater systems	*4*		**FALSE**
		Fit a water meter	*1*		**TRUE**
			Subtotal	**8**	
Please give any additional relevant comments to the Improving Resource Efficiency Section below					

7	**ACCESSIBILITY**				
7.1	**Ensure flexible adaptable and long-term use of structures**				
a.	**If the development is residential,** will it meet the requirements of the nationally described space standard for internal space and layout?		*1*		**Please Select:**
	If the standards are not met, in the space below, please provide details of the functionality of the internal space and layout				
AND					
b.	**If the development is residential**, will it meet Building Regulation Requirement M4 (2) 'accessible and adaptable dwellings'?		*2*		**Please Select:**
	If this is not met, in the space below, please provide details of any accessibility measures included in the development.				
	For major residential developments, are 10% or more of the units in the development to Building Regulation Requirement M4 (3) 'wheelchair user dwellings'?		*1*		**Please Select:**
OR					
c.	**If the development is non-residential,** does it comply with requirements included in Richmond's Local Plan LP1, LP28.B, LP30 & LP45		*2*		**TRUE**
	Please provide details of the accessibility measures specified in the Local Plan that will be included in the development	Access to the site from Whitton Dene at the northwest of the Site will be re-opened for staff and servicing vehicle activity. There will also be a new pedestrian gate access adjacent to the existing vehicle access at the south of the Site onto Kneller			
			Subtotal	**2**	
Please give any additional relevant comments to the Design Standards and Accessibility Section below					

LBRUT Sustainable Construction Checklist- Scoring Matrix for *New Construction* **(Non-Residential and domestic refurb)** ***TOTAL*** ***71.5***

Score	Rating	Significance
84 or more	*A+*	Project strives to achieve highest standard in energy efficient sustainable development
75-83	*A*	Makes a major contribution towards achieving sustainable development in Richmond
56-74	*B*	Helps to significantly improve the Borough's stock of sustainable developments
40-55	*C*	Minimal effort to increase sustainability beyond general compliance
39 or less	*FAIL*	Does not comply with SPD Policy

LBRUT Sustainable Construction Checklist- Scoring Matrix for New Construction **Residential new-build**

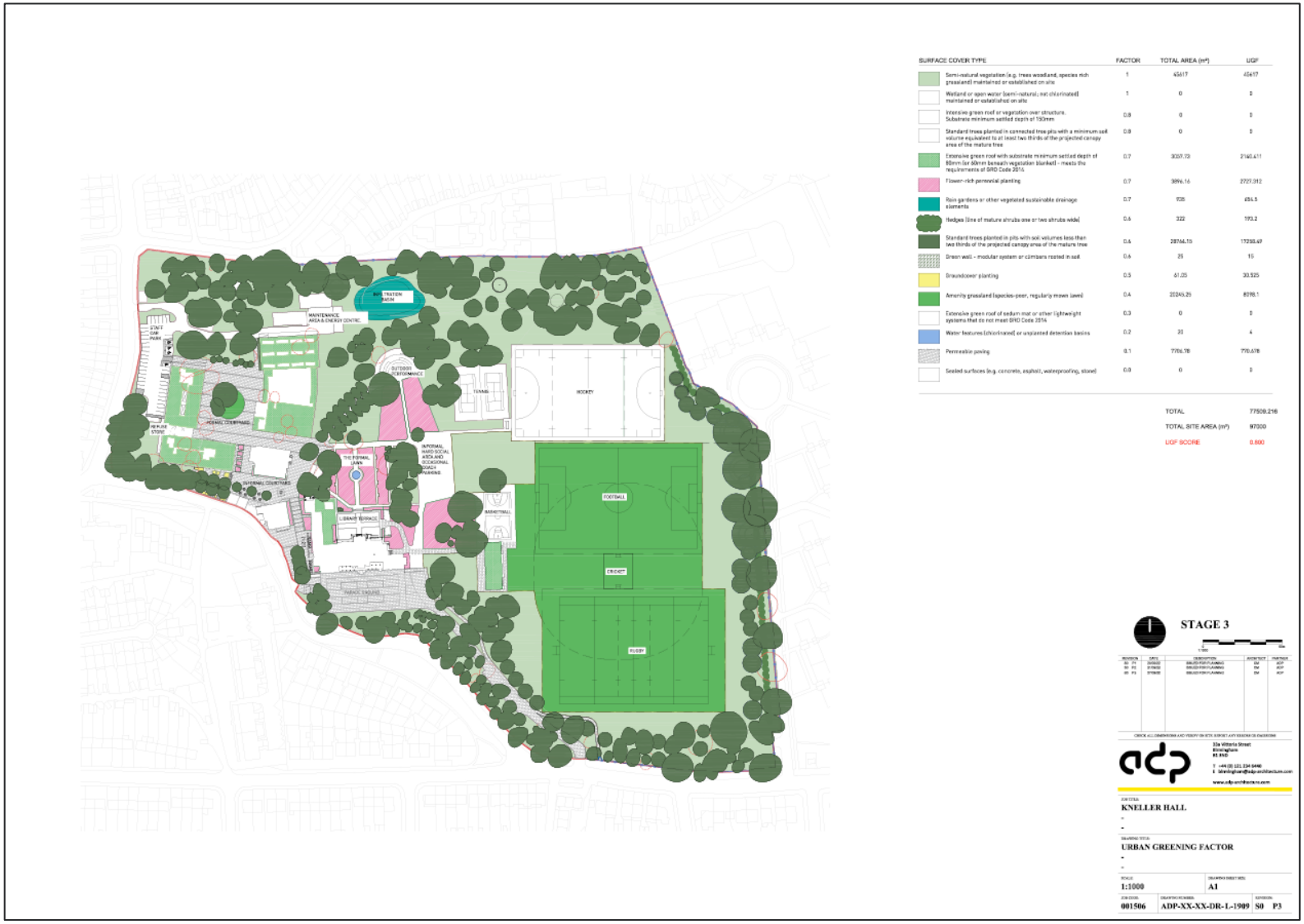
Score	Rating	Significance
85 or more	A++	Project strives to achieve highest standard in energy efficient sustainable development
68-84	*A+*	Project strives to achieve higher standard in energy efficient sustainable development
59-67	*A*	Makes a major contribution towards achieving sustainable development in Richmond
39-58	*B*	Helps to significantly improve the Borough's stock of sustainable developments
24-38	*C*	Minimal effort to increase sustainability beyond general compliance
23 or less	*FAIL*	Does not comply with SPD Policy

Authorisation:

I herewith declare that I have filled in this form to the best of my knowledge

Signature _____ **Date** _____

Appendix F – Urban Greening Factor



SURFACE COVER TYPE	FACTOR	TOTAL AREA (m²)	UGF
Semi-natural vegetation (e.g. trees woodland, species rich grassland) maintained or established on site	1	45617	45617
Wetland or open water (semi-natural; not chlorinated) maintained or established on site	1	0	0
Intensive green roof or vegetation over structure. Substrate minimum settled depth of 150mm	0.8	0	0
Standard trees planted in connected tree pits with a minimum soil volume equivalent to at least two thirds of the projected canopy area of the mature tree	0.8	0	0
Extensive green roof with substrate minimum settled depth of 80mm (or 60mm beneath vegetation blanket) - meets the requirements of GRO Code 2014	0.7	3037.72	2140.411
Flower-rich perennial planting	0.7	3896.16	2727.312
Rain gardens or other vegetated sustainable drainage elements	0.7	935	654.5
Hedges (line of mature shrubs one or two shrubs wide)	0.6	322	193.2
Standard trees planted in pits with soil volumes less than two thirds of the projected canopy area of the mature tree	0.6	29744.15	17258.47
Green wall - modular system or climbers rooted in soil	0.6	25	15
Groundcover planting	0.5	61.05	30.525
Amenity grassland (species-poor, regularly mown lawn)	0.4	20245.25	8098.1
Extensive green roof of sedum mat or other lightweight systems that do not meet GRO Code 2014	0.3	0	0
Water features (chlorinated) or unplanted detention basins	0.2	20	4
Permeable paving	0.1	7706.78	770.678
Sealed surfaces (e.g. concrete, asphalt, waterproofing, stone)	0.0	0	0
TOTAL			77509.216
TOTAL SITE AREA (m²)			97000
UGF SCORE			0.800

STAGE 3

KNELLER HALL

URBAN GREENING FACTOR

1:1000 | A1

001506 | ADP-XX-XX-DR-L-1909 | S0 | P3

SURFACE COVER TYPE	FACTOR	TOTAL AREA (m²)	UGF
Semi-natural vegetation (e.g. trees woodland, species rich grassland) maintained or established on site	1	45617	45617
Wetland or open water (semi-natural; not chlorinated) maintained or established on site	1	0	0
Intensive green roof or vegetation over structure. Substrate minimum settled depth of 150mm	0.8	0	0
Standard trees planted in connected tree pits with a minimum soil volume equivalent to at least two thirds of the projected canopy area of the mature tree	0.8	0	0
Extensive green roof with substrate minimum settled depth of 80mm (or 60mm beneath vegetation blanket) - meets the requirements of GRO Code 2014	0.7	2938	2056.6
Flower-rich perennial planting	0.7	3896.16	2727.312
Rain gardens or other vegetated sustainable drainage elements	0.7	935	654.5
Hedges (line of mature shrubs one or two shrubs wide)	0.6	322	193.2
Standard trees planted in pits with soil volumes less than two thirds of the projected canopy area of the mature tree	0.6	28764.15	17258.49
Green wall - modular system or climbers rooted in soil	0.6	25	15
Groundcover planting	0.5	61.05	30.525
Amenity grassland (species-poor, regularly mown lawn)	0.4	20245.25	8098.1
Extensive green roof of sedum mat or other lightweight systems that do not meet GRO Code 2014	0.3	0	0
Water features (chlorinated) or unplanted detention basins	0.2	20	4
Permeable paving	0.1	7706.78	770.678
Sealed surfaces (e.g. concrete, asphalt, waterproofing, stone)	0.0	0	0

TOTAL	77425.405
TOTAL SITE AREA (m²)	97000
UGF SCORE	0.798

Appendix G – BRUKL (New Developments)

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

Kneller Hall - New_PV

As designed

Date: Wed Sep 07 12:47:12 2022

Administrative information

Building Details

Address: Twickenham, London, TW2 7DU

Certifier details

Name: Yin Mui Tang

Telephone number: 01730 710044

Address: SRE Ltd, 1 Farnham Rd, Guildford, GU2 4RG

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.16

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.16

BRUKL compliance module version: v6.1.c.0

Foundation area [m²]: 1062.72

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	4.58	
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	1.36	
Target primary energy rate (TPER), $kWh/m^2.annum$	44.55	
Building primary energy rate (BPER), $kWh/m^2.annum$	8.64	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.14	0.14	CR00000D:Surf[2]
Floors	0.18	0.1	0.1	RM0001D1:Surf[0]
Pitched roofs	0.16	0.12	0.12	BR000003:Surf[6]
Flat roofs	0.18	0.1	0.13	CH000004:Surf[13]
Windows** and roof windows	1.6	0.82	1.2	RM0001F3:Surf[2]
Rooflights***	2.2	0.89	0.9	RM000203:Surf[51]
Personnel doors^	1.6	1.2	1.2	RM0001F3:Surf[2]
Vehicle access & similar large doors	1.3	-	-	No Vehicle access doors in building
High usage entrance doors	3	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [W/(m²K)]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m²K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	3

Page 1 of 15

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Centralised ASHP -serving underfloor heating with MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.					

2- Sports Centre FCU Active Cooling

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.66	5.5	0	1.2	0.8
Standard value	2.5*	4.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps. ** Standard shown is for air-cooled chillers >=400 kW. For chillers <400 kW, limiting SEER is 4. ^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.					

3- Centralised ASHP-local WSHP serving oversized radiators + natvent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.					

4- Centralised ASHP local WSHP-serving oversized radiators with MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.					

5- Teaching Block GSHP + natvent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.28	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES
* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.					

6- Teaching Block AHU with heating/cooling and HR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.66	5.5	0	1.1	0.8
Standard value	2.5*	4.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for air-cooled chillers >=400 kW. For chillers <400 kW, limiting SEER is 4.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

7- Teaching Block GSHP + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.28	-	0.2	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

8- Centralised ASHP local WSHP-serving UF heating + extract

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

9- Centralised ASHP local WSHP-serving oversized radiators with extract vent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

10- Teaching Block GSHP + extract

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.28	-	0.2	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

1- Centralised ASHP+ GSHP serving HWS New

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	3.65	0.006
Standard value	1	N/A

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter
NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.	

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
Acc Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Acc Shower	-	-	-	1.1	-	-	-	-	-	-	N/A
Acc WC	-	-	-	1.1	-	-	-	-	-	-	N/A
Acc WC	-	-	-	1.1	-	-	-	-	-	-	N/A
Acc WC	-	-	-	1.1	-	-	-	-	-	-	N/A
Acc WC	-	-	-	1.1	-	-	-	-	-	-	N/A
Acc WC	-	-	-	1.1	-	-	-	-	-	-	N/A
Activity Studio	-	-	-	-	-	-	-	0.3	-	-	N/A
Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing room	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing room	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing room	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing room	-	-	-	1.1	-	-	-	-	-	-	N/A
Circulation	-	-	-	1.1	-	-	-	-	-	-	N/A
Corridor	-	-	-	1.1	-	-	-	-	-	-	N/A
Corridor/Balcony	-	-	-	1.1	-	-	-	-	-	-	N/A
Dining Hall	-	-	-	-	-	-	-	1.1	-	-	N/A
Dry changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Dry changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Dry Changing Area	-	-	-	1.1	-	-	-	-	-	-	N/A
Dry Changing area	-	-	-	1.1	-	-	-	-	-	-	N/A
Entrance lobby	-	-	-	1.1	-	-	-	-	-	-	N/A
First Aid	-	-	-	1.1	-	-	-	-	-	-	N/A
Fitness Studio	-	-	-	-	-	-	-	0.3	-	-	N/A
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General Classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
ICT classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
Lobby	-	-	-	1.1	-	-	-	-	-	-	N/A
Plant Room	-	-	-	1.1	-	-	-	-	-	-	N/A
Pool Plant	-	-	-	1.1	-	-	-	-	-	-	N/A
Reception	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Shower	0.3	-	-	-	-	-	-	-	-	-	N/A
Shower	0.3	-	-	-	-	-	-	-	-	-	N/A
Shower	0.3	-	-	-	-	-	-	-	-	-	N/A
Shower	0.3	-	-	-	-	-	-	-	-	-	N/A
Shower	0.3	-	-	-	-	-	-	-	-	-	N/A
Sports Hall	-	-	-	1.1	-	-	-	-	-	-	N/A
Staff Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Stairs	-	-	-	1.1	-	-	-	-	-	-	N/A
Stairs	-	-	-	1.1	-	-	-	-	-	-	N/A
Stairs	-	-	-	1.1	-	-	-	-	-	-	N/A
Stairs	-	-	-	1.1	-	-	-	-	-	-	N/A
Studio Changing Area	-	-	-	1.1	-	-	-	-	-	-	N/A
Swimming Pool	-	-	-	1.1	-	-	-	-	-	-	N/A
Viewing Area	-	-	-	1.1	-	-	-	-	-	-	N/A
Waiting/Informal Seating Area	-	-	-	1.1	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	-	-	-	1.1	-	-	-	-	-	-	N/A
WC	-	-	-	1.1	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
Wet Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Wet Changing	-	-	-	1.1	-	-	-	-	-	-	N/A
Science Office	-	-	-	1.1	-	-	-	-	-	-	N/A
Staff room	-	-	-	1.1	-	-	-	-	-	-	N/A
Kitchen	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
Office	-	-	-	1.1	-	-	-	-	-	-	N/A
Changing	0.3	-	-	-	-	-	-	-	-	-	N/A
Cold Store	0.3	-	-	-	-	-	-	-	-	-	N/A
Freezer	0.3	-	-	-	-	-	-	-	-	-	N/A
ICT classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
ICT classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
ICT classroom	-	-	-	1.1	-	-	-	-	-	-	N/A
General classroom	-	-	-	1.1	-	-	-	-	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Acc Changing	125	-	-
Acc Shower	125	-	-
Acc WC	125	-	-
Acc WC	125	-	-
Acc WC	125	-	-
Acc WC	125	-	-
Acc WC	125	-	-
Activity Studio	125	-	-
Activity Studio Storage	125	-	-
Breakout space/Foyer	125	-	-
Chair Store	125	-	-
Changing	125	-	-
Changing	125	-	-
Changing	125	-	-
Changing	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Changing	125	-	-
Changing room	125	-	-
Changing room	125	-	-
Changing room	125	-	-
Changing room	125	-	-
chemical store	125	-	-
Chemical Store	125	-	-
Chemical Store	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
circulation	125	-	-
Circulation	125	-	-
circulation	125	-	-
circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Cleaner Store	125	-	-
Cleaner's store	125	-	-
Club room	125	-	-
Corridor	125	-	-
Corridor/Balcony	125	-	-
Cupboard	125	-	-
Cupboard	125	-	-
Cupboard	125	-	-
cupboard	125	-	-
Dining Hall	125	-	-
Dressing room	125	-	-
Dressing room	125	-	-
Dry changing	125	-	-
Dry changing	125	-	-
Dry Changing Area	125	-	-
Dry Changing area	125	-	-
DT1	125	-	-
DT3	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
DT4	125	-	-
Entrance lobby	125	15	9
First Aid	125	-	-
Fitness Studio	125	-	-
Fitness Studio Storage	125	-	-
General Classroom	125	-	-
General classroom	125	-	-
General Classroom	125	-	-
General classroom	125	-	-
General classroom	125	-	-
General Classroom	125	-	-
General classroom	125	-	-
General Classroom	125	-	-
General Classroom	125	-	-
General classroom	125	-	-
General Classroom	125	-	-
General classroom	125	-	-
General Classroom	125	-	-
General classroom	125	-	-
Green Room	125	-	-
ICT classroom	125	-	-
Library & Learning	125	-	-
Library & Learning	125	-	-
Lobby	125	-	-
Lobby	125	-	-
Lobby	125	-	-
Multi-materials room	125	-	-
WC	125	-	-
Plant room	125	-	-
Plant Room	125	-	-
Pool Plant	125	-	-
Pool Storage	125	-	-
Reception	125	15	9
Fitness Studio Storage	125	-	-
Changing	125	-	-
science classroom	125	-	-
Science classroom	125	-	-
Science Classroom	125	-	-
Science Classroom	125	-	-
Science Classroom	125	-	-
science prep room	125	-	-
Seminar room	125	-	-
Shower	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Shower	125	-	-
Shower	125	-	-
Shower	125	-	-
Shower	125	-	-
Shower WC	125	-	-
Sports Hall	125	-	-
Sports Hall Storage	125	-	-
Staff Area	125	-	-
Staff Changing	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Store	125	-	-
Store	125	-	-
Studio Changing Area	125	-	-
Swimming Pool	125	-	-
Viewing Area	125	-	-
Waiting/Informal Seating Area	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC circulation	125	-	-
WC circulation	125	-	-
WC Circulation	125	-	-
WC Circulation	125	-	-
WC circulation	125	-	-
WC circulation	125	-	-
WC Circulation	125	-	-
WC circulation	125	-	-
Wc circulation	125	-	-
WC circulation	125	-	-
WC Circulation	125	-	-
WC Circulation	125	-	-
WC circulation	125	-	-
WC circulation	125	-	-
WC circulation	125	-	-
WC Circulation	125	-	-
Wet Changing	125	-	-
Wet Changing	125	-	-
Science Office	125	-	-
Science Classroom	125	-	-
Staff area	125	-	-
Store	125	-	-
Breakout	125	-	-
DT2	125	-	-
Staff room	125	-	-
Pastoral Suite	125	-	-
Kitchen	125	-	-
WC	125	-	-
Office	125	-	-
Changing	125	-	-
Dry Store	125	-	-
Cold Store	125	-	-
Freezer	125	-	-
Dishwash	125	-	-
Servery	125	-	-
Stairs	125	-	-
ICT classroom	125	-	-
ICT classroom	125	-	-
ICT classroom	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Science Classroom	125	-	-
Science Classroom	125	-	-
Science prep room	125	-	-
Circulation	125	-	-
General classroom	125	-	-
Breakout space	125	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Acc Changing	N/A	N/A
Activity Studio	NO (-6%)	NO
Activity Studio Storage	NO (-100%)	NO
Breakout space/Foyer	YES (+57.9%)	NO
Changing	N/A	N/A
Changing	N/A	N/A
Changing	N/A	N/A
Changing	N/A	N/A
Changing	N/A	N/A
Changing room	NO (-82.5%)	NO
Changing room	NO (-78%)	NO
Changing room	NO (-73%)	NO
Changing room	NO (-76.8%)	NO
Chemical Store	N/A	N/A
Chemical Store	N/A	N/A
Cleaner Store	N/A	N/A
Cleaner's store	N/A	N/A
Club room	NO (-31.4%)	NO
Dining Hall	NO (-33%)	NO
Dressing room	N/A	N/A
Dressing room	N/A	N/A
Dry changing	N/A	N/A
Dry changing	N/A	N/A
Dry Changing Area	N/A	N/A
Dry Changing area	N/A	N/A
DT1	NO (-55.2%)	NO
DT3	NO (-56.6%)	NO
DT4	NO (-57.1%)	NO
Entrance lobby	YES (+5.5%)	NO
First Aid	N/A	N/A
Fitness Studio	N/A	N/A
Fitness Studio Storage	NO (-99.9%)	NO
General Classroom	NO (-65.2%)	NO
General classroom	NO (-45.1%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
General Classroom	NO (-54.8%)	NO
General classroom	NO (-35.5%)	NO
General classroom	NO (-32.6%)	NO
General Classroom	NO (-38.3%)	NO
General classroom	NO (-34.1%)	NO
General Classroom	NO (-33.5%)	NO
General Classroom	NO (-42.4%)	NO
General classroom	NO (-61.1%)	NO
General Classroom	NO (-37.3%)	NO
General classroom	NO (-38.8%)	NO
General Classroom	NO (-33.5%)	NO
General classroom	NO (-57.4%)	NO
Green Room	NO (-42.3%)	NO
ICT classroom	NO (-66.6%)	NO
Library & Learning	NO (-89%)	NO
Library & Learning	NO (-45%)	NO
Pool Storage	N/A	N/A
Reception	N/A	N/A
Fitness Studio Storage	N/A	N/A
Changing	N/A	N/A
science classroom	NO (-26.3%)	NO
Science classroom	NO (-36.3%)	NO
Science Classroom	NO (-25.3%)	NO
Science Classroom	NO (-28.4%)	NO
Science Classroom	NO (-66.4%)	NO
science prep room	NO (-27.8%)	NO
Seminar room	NO (-56.5%)	NO
Sports Hall	NO (-40.1%)	NO
Sports Hall Storage	N/A	N/A
Staff Area	NO (-67.6%)	NO
Staff Changing	N/A	N/A
Store	N/A	N/A
Studio Changing Area	N/A	N/A
Swimming Pool	NO (-22.8%)	NO
Viewing Area	NO (-20.7%)	NO
Waiting/Informal Seating Area	N/A	N/A
Science Office	NO (-24.6%)	NO
Science Classroom	NO (-29.8%)	NO
Staff area	NO (-34%)	NO
Breakout	NO (-27%)	NO
DT2	NO (-38.8%)	NO
Staff room	N/A	N/A
Pastoral Suite	NO (-44.3%)	NO
Office	NO (-2.8%)	NO
Changing	N/A	N/A
ICT classroom	NO (-31.7%)	NO
ICT classroom	NO (-37.4%)	NO
ICT classroom	NO (-40.1%)	NO
Science Classroom	NO (-36.5%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Science Classroom	NO (-41.6%)	NO
Science prep room	NO (-24.1%)	NO
General classroom	NO (-24.7%)	NO
Breakout space	NO (-35.6%)	NO

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m^2]	8802.3	8802.3
External area [m^2]	14521.6	14171.4
Weather	LON	LON
Infiltration [m^3/hm^2@ 50Pa]	3	3
Average conductance [W/K]	2829.89	4048.04
Average U-value [W/m^2K]	0.19	0.29
Alpha value* [%]	25.8	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
63	**Non-residential Institutions: Education**
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
37	**General Assembly and Leisure, Night Clubs, and Theatres**
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m^2]

	Actual	Notional
Heating	7.44	9.42
Cooling	0.23	0.13
Auxiliary	7.34	4.17
Lighting	6.62	9.39
Hot water	8.39	9.67
Equipment*	26.13	26.13
TOTAL**	30.02	32.79

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m^2]

	Actual	Notional
Photovoltaic systems	22.69	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*22.69*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m^2]	90.58	99.63
Primary energy [kWh/m^2]	8.64	44.55
Total emissions [kg/m^2]	1.36	4.58

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	103	0	8.2	0	1.7	3.49	0	3.71	0
	Notional	118.5	0	10.9	0	0.9	3.01	0	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	267.9	0	21.3	0	5.7	3.49	0	3.71	0
	Notional	105	0	9.7	0	4.1	3.01	0	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	23.6	0	2.1	0	15.2	3.08	0	3.28	0
	Notional	54.5	0	5.4	0	1.5	2.78	0	----	----
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	14.5	34.8	1.3	2.2	10.2	3.19	4.47	3.66	5.5
	Notional	10.7	22.8	1.1	1.4	4	2.78	4.63	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	47.5	0	3.8	0	8.5	3.49	0	3.71	0
	Notional	87.4	0	8.1	0	3.1	3.01	0	----	----
[ST] Central heating using water: floor heating, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	239.2	0	19	0	2.4	3.49	0	3.71	0
	Notional	772.5	0	71.3	0	1.2	3.01	0	----	----
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	4.7	65.4	0.4	4.1	36.9	3.21	4.44	3.66	5.5
	Notional	7.1	34.2	0.7	2.1	39	2.78	4.63	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	133.2	0	12	0	1.8	3.08	0	3.28	0
	Notional	305.6	0	30.5	0	0.7	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	47.9	0	4.3	0	2.2	3.08	0	3.28	0
	Notional	64.3	0	6.4	0	1.6	2.78	0	----	----
[ST] Central heating using water: floor heating, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	94.3	0	7.5	0	9.4	3.49	0	3.71	0
	Notional	13.2	0	1.2	0	4.3	3.01	0	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Appendix H – BRUKL (Existing Buildings)

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

Kneller Hall - Existing — As designed

Date: Wed Sep 07 12:59:23 2022

Administrative information

Building Details

Address: Twickenham, London, TW2 7DU

Certifier details

Name: Yin Mui Tang

Telephone number: 01730 710044

Address: SRE Ltd, 1 Farnham Rd, Guildford, GU2 4RG

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.16

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.16

BRUKL compliance module version: v6.1.c.0

Foundation area [m²]: 503.22

The CO_2 emission and primary energy rates of the building must not exceed the targets

The building does not comply with England Building Regulations Part L 2021

Target CO_2 emission rate (TER), $kgCO_2/m^2$annum	3.63	
Building CO_2 emission rate (BER), $kgCO_2/m^2$annum	8.52	
Target primary energy rate (TPER), kWh/m^2annum	18.6	
Building primary energy rate (BPER), kWh/m^2annum	17.79	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	2.11	2.4	6T000006:Surf[0]
Floors	0.18	0.68	1.2	DN000004:Surf[7]
Pitched roofs	0.16	2.3	2.3	DT000004:Surf[8]
Flat roofs	0.18	1.11	2.3	RM0001C7:Surf[1]
Windows** and roof windows	1.6	4.8	4.8	FR00000D:Surf[0]
Rooflights***	2.2	-	-	No roof lights in building
Personnel doors^	1.6	3	3	DN000004:Surf[5]
Vehicle access & similar large doors	1.3	-	-	No Vehicle access doors in building
High usage entrance doors	3	-	-	No High usage entrance doors in building

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m^2K)] — $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [W/(m^2K)]

$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m^2K)]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m^2K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	25

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Centralised ASHP-local WSHP serving oversized radiators + natvent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

2- School Hall AHU with heating/cooling and HR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	5.5	0	1.1	0.8
Standard value	2.5*	4.5**	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

** Standard shown is for air-cooled chillers >=400 kW. For chillers <400 kW, limiting SEER is 4.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

3- Centralised ASHP local WSHP-serving oversized radiators with MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	0.8
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

4- Centralised ASHP local WSHP-serving oversized radiators with extract vent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

5- Centralised ASHP -serving oversized radiators with natvent

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.71	-	0.2	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

1- Centralised ASHP+ GSHP serving HWS Existing

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	3.65	0.006
Standard value	1	N/A

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
Auditorium	-	-	-	-	-	-	-	1.1	-	-	N/A
Music practice room	-	-	-	1.1	-	-	-	-	-	-	N/A
Music practice room	-	-	-	1.1	-	-	-	-	-	-	N/A
Music practice room	-	-	-	1.1	-	-	-	-	-	-	N/A
Music practice room	-	-	-	1.1	-	-	-	-	-	-	N/A
Music practice room	-	-	-	1.1	-	-	-	-	-	-	N/A
W.C. & D.W.C	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A
WC	0.3	-	-	-	-	-	-	-	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
6th Form class 1	125	-	-
6th Form class 2	125	-	-
6th Form class 3	125	-	-
6th Form class 4	125	-	-
6th Form class 5	125	-	-
6th Form class 6	125	-	-
6th Form Class 7	125	-	-
6th Form Class 8	125	-	-
6th Form Class 9	125	-	-
6th form classroom	125	-	-
6th Form Common Room	125	-	-
6th Form study	125	-	-
6th Form study	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
Art	125	-	-
Art	125	-	-
Art	125	-	-
Auditorium	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
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Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Basement Mechanical and Electrical	125	-	-
Cafe	125	-	-
Chapel	125	-	-
Chapel	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
circulation	125	-	-
circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
circulation	125	-	-
circulation	125	-	-
circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Circulation	125	-	-
Control Room	125	-	-
Drama /Lecture Space	125	-	-
Entrance	125	-	-
Entrance LKobby	125	-	-
Entrance lobby	125	-	-
General classroom	125	-	-
General classroom	125	-	-
General classroom	125	-	-
General classroom	125	-	-
General classroom	125	-	-
General office	125	-	-
Hall	125	-	-
Headmaster	125	-	-
Library	125	-	-
Library	125	-	-
Meeting Room	125	-	-
Music classroom	125	-	-
Music Classroom	125	-	-
Music Deparment Office	125	-	-
Music practice room	125	-	-
Music practice room	125	-	-
Music practice room	125	-	-
Music practice room	125	-	-
Music Store	125	-	-
Music practice room	125	-	-
Music Store	125	-	-
Music&Creative Tech Classroom	125	-	-
plant	125	-	-
Recording Studio	125	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
School Leadership	125	-	-
School nurse	125	-	-
Secruity Mess Room	125	-	-
Security Office	125	-	-
Seminar Room	125	-	-
Services	125	-	-
Sick Bay	125	-	-
Staff Room	125	-	-
Staff Work/Room / Office	125	-	-
Staff Work/Room / Office	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase	125	-	-
Staircase/Circulation	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stairs	125	-	-
Stoarge	125	-	-
Store	125	-	-
store	125	-	-
store	125	-	-
store	125	-	-
Store	125	-	-
Store	125	-	-
Store	125	-	-
Switch room	125	-	-
W.C. & D.W.C	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
WC	125	-	-
Store	125	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
6th Form class 1	NO (-99.9%)	NO
6th Form class 2	YES (+6.1%)	NO
6th Form class 3	N/A	N/A
6th Form class 4	NO (-62.1%)	NO
6th Form class 5	NO (-58.3%)	NO
6th Form class 6	NO (-24.4%)	NO
6th Form Class 7	NO (-44.6%)	NO
6th Form Class 8	NO (-44.5%)	NO
6th Form Class 9	NO (-46.6%)	NO
6th form classroom	NO (-67.5%)	NO
6th Form Common Room	NO (-48%)	NO
6th Form study	NO (-42.2%)	NO
6th Form study	NO (-44.9%)	NO
Art	NO (-73%)	NO
Art	NO (-67%)	NO
Art	NO (-51.6%)	NO
Auditorium	NO (-82%)	NO
Cafe	NO (-61%)	NO
Chapel	YES (+38.3%)	NO
Chapel	YES (+26.5%)	NO
Control Room	NO (-70.8%)	NO
Drama /Lecture Space	NO (-55.2%)	NO
General classroom	NO (-56.5%)	NO
General classroom	NO (-75.9%)	NO
General classroom	NO (-77.4%)	NO
General classroom	NO (-51.9%)	NO
General classroom	NO (-53.6%)	NO
General office	N/A	N/A
Hall	NO (-61%)	NO
Headmaster	NO (-55.8%)	NO
Library	NO (-21.6%)	NO
Library	NO (-56.2%)	NO
Meeting Room	NO (-59.1%)	NO
Music classroom	NO (-60%)	NO
Music Classroom	NO (-86.1%)	NO
Music Deparment Office	NO (-68.7%)	NO
Music practice room	NO (-84.2%)	NO
Music practice room	NO (-33.5%)	NO
Music practice room	N/A	N/A
Music practice room	NO (-64%)	NO
Music practice room	N/A	N/A
Music&Creative Tech Classroom	NO (-36.5%)	NO
Recording Studio	NO (-85.3%)	NO
School Leadership	NO (-23.3%)	NO

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
School nurse	NO (-76.8%)	NO
Secruity Mess Room	NO (-90.3%)	NO
Security Office	NO (-76.3%)	NO
Seminar Room	NO (-58.2%)	NO
Sick Bay	NO (-99.9%)	NO
Staff Room	NO (-38.1%)	NO
Staff Work/Room / Office	NO (-85.5%)	NO
Staff Work/Room / Office	N/A	N/A

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	4387.1	4387.1
External area [m²]	7725.5	7542.3
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	25	3
Average conductance [W/K]	15715.4	2742.18
Average U-value [W/m²K]	2.03	0.36
Alpha value* [%]	24.25	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
100	**Non-residential Institutions: Education**
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	44.97	12.83
Cooling	0.05	0.04
Auxiliary	3.74	1.38
Lighting	5.01	6.6
Hot water	2.91	4.41
Equipment*	57.24	57.24
TOTAL**	**56.68**	**25.26**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	562.08	139.74
Primary energy [kWh/m²]	17.79	18.6
Total emissions [kg/m²]	8.52	3.63

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	682.8	0	54.4	0	1.7	3.49	0	3.71	0
	Notional	62.3	0	5.7	0	0.9	3.01	0	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	712.8	0	56.7	0	2.8	3.49	0	3.71	0
	Notional	71.1	0	6.6	0	1.7	3.01	0	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	549.6	0	43.8	0	4	3.49	0	3.71	0
	Notional	76.4	0	7	0	1.5	3.01	0	----	----
[ST] Central heating using water: radiators, [HS] GSHP/WSHP, [HFT] Electricity, [CFT] Electricity										
	Actual	808.9	0	64.4	0	2.4	3.49	0	3.71	0
	Notional	181.4	0	16.7	0	1.2	3.01	0	----	----
[ST] Fan coil systems, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	979.6	16.7	84.1	1	53	3.23	4.47	3.71	5.5
	Notional	99.5	16.2	9.2	1	8.9	3.01	4.63	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

SRE Registered Office | Greenforde Farm
Stoner Hill Road | Froxfield
Petersfield | Hampshire | GU32 1DY
01730 710044
info@sre.co.uk
www.sre.co.uk